AFIT/GLM/LSY/93S-19

ANALYSIS AND DEVELOPMENT OF AN F-5 POLLUTION PREVENTION MANAGEMENT PROGRAM WITH RECOMMENDATIONS FOR CREATION OF SIMILAR PROGRAMS FOR OTHER AIRCRAFT

THESIS

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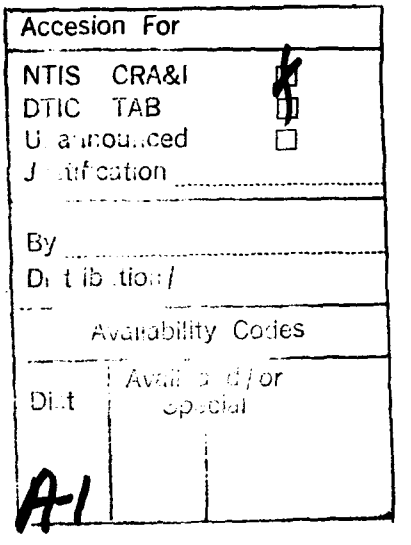

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ANALYSIS AND DEVELOPMENT OF AN F-5 POLLUTION PREVENTION MANAGEMENT PROGRAM WITH RECOMMENDATIONS FOR CREATION OF SIMILAR PROGRAMS FOR OTHER AIRCRAFT

THESIS

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Janice M. Gavern, B.S.

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and

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Finally, to my darling, irascible, incredible, wonderful daughter, Lisa Jeanne Goodman. I dedicate this thesis to you, in the hope that it will help make the Earth your children inherit a better place in which to live. Love, Mom.

Janice M. Gavern

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Abstract

This study developed a pollution prevention management program for the F-5 aircraft, and described its utility and applicability as a generic framework for similar programs. A representative set of F-5 technical orders was analyzed by hand, and the identified chemicals, materials, and processes were loaded into a spreadsheet data base for additional analysis. The Environmental Protection Agency (EPA) list of 17 targeted industrial chemicals, and other lists of ozone depleting chemicals (ODCs) were used as criteria to identify, for minimization, reduction, or elimination from use on the F-5, a hazardous material (hazmat) subset of those chemicals and materials which had already been identified. The identified hazmat substances were then "rolled-up" into an F-5 Pollution Prevention Management Plan. Program management use and implementation of the information set out in such a plan were also described. Recommendations for additional research and development, and for required tools were included. Finally, actual examples of all of the material created were attached to the document.

Analysis and Development of an F-5 Pollution Prevention Management Program With Recommendations for Creation of Similar Programs for Other Aircraft

I. Introduction

General Issue

In the last twenty years, our knowledge of environmental problems has reached a global perspective. At the same time, we are only beginning to understand the concept of global environmental health. Concerned citizens and Environmental Protection Agency (EPA) personnel are not the only ones who are upset and determined to do something about it. (25; 82:181-188; 92) The Department of Defense (DoD) has identified *10,924 hazardous hot spots at 1,877 installations, including 123 of the Superfund's 1,236 sites (100:69). The cost to clean up the mess has been estimated as much as '$120 billion' (100:69).* Other problems have occurred when military bases were selected for closure, and the problems of transferring the land to civilian uses were blocked or delayed because of pollution and the cost and time necessary for cleanup (79:770-772).

The problem is not limited to our country alone. *A 1991 Air Force report estimated $100 million to clean up 39 bases in 11 foreign nations. In Canada alone, it will cost more than $61 million...it will cost $42.3 million to restore just three bases in Germany (84:29).* In his article "Toxic Military", Peto Pieth, a Swiss journalist, points out that *the world's armed forces are the single biggest polluters on the planet (80:773).*

Section 101 (c) of the Clean Water Act (95) states that:

> *It is further the policy of Congress that the President, acting through the Secretary of State and such national and international organizations as he determines appropriate, shall take such action as may be necessary to insure that to the fullest extent possible all foreign countries shall take meaningful action for the prevention, reduction and elimination of pollution in their waters and in international waters and for the achievement of goals regarding the elimination of discharge of pollutants and the improvement of water quality to at least the same extent as the United States does under its laws. (95)*

In addition, recent scientific evidence has shown unmistakable damage to the ozone layer that protects the earth from harmful ultraviolet rays. The hole in the ozone layer now exposes inhabited areas to the potentially damaging sunlight. The impact of this occurrence may never be completely understood. (37:24-32)

Finally, everyone from CEOs, agency heads, generals, and commanders, to key managers, supervisors and individuals are concerned about the possibility of being prosecuted for environmental crimes and criminal liability (59:131).

The result of all of the problems described above is a new interest and concern for environmental protection and pollution prevention. (82:181-188)

Specific Problem

One significant goal of the Air Force is the reduction of hazardous waste at its source. (69) In the case of the Air Force, the source is the aircraft. Numerous efforts are underway to accomplish that goal for the active duty Air Force. Unfortunately, similar efforts are not underway for weapons systems which are no longer in the active inventory, but which the U.S. government has sold to foreign countries (101). In addition, Air Force Regulation 19-15 (27) would require that *offices that transfer or sell any Air Force developed technology or products which depend on ODCs must notify the Air Staff of any transaction which transfers dependence outside the Air Force (68:13).*

At the time this thesis research was undertaken, there were not any Air Force weapon system Pollution Prevention Management Programs in place which had not been

accomplished by a contracted effort. Although I am still not aware of any such programs, there may be some underway which have not yet been reported. My goal was to determine if it was possible to develop such a program without a contractor, using government resources, and searching the technical orders by-hand. If it was, I would create the program, together with the products which would be necessary to implement it. I chose the F-5 aircraft (Figure 1) as my test case because, as an aircraft maintenance officer in the Category B Air Force Reserve program, I am assigned to the organization at San Antonio Air Logistics Center which provides logistics support for the F-5. In addition, the products, processes and technology used in maintaining the F-5 are common to a number of Air Force weapon systems, making crossfeed of information more important and relevant. Finally, a Pollution Prevention Management Program would demonstrate the capability to provide our allies with information on approved alternatives to required hazardous materials to support their own environmental protection programs.

Primary Research Objectives

Various models of the F-5 aircraft are flown by countries which are allies of the United States. A significant amount of documentation is readily available for the F-5 through the Proven Aircraft Division, San Antonio Air Logistics Center, Kelly AFB, Texas. This thesis effort used some of that documentation as the basis for an analysis of hazardous and toxic materials as they are required on the F-5 today.

Once the analysis was accomplished, a preliminary risk analysis was conducted on the identified materials. The identified chemicals and materials were grouped into management categories, with an identified chemical or material which is tracked in more than one system (explosive as well as hazardous, for example) at the top of the list, and those chemicals and materials which have not been identified as a hazard (petrolatum, for example) at the bottom of the list. As more chemicals and materials are identified, further groupings within these management categories will be accomplished. This next level of

Figure 1. F-5 Aircraft

grouping will be based on the actual risk analysis of the chemicals and materials, and will also include operational and maintenance processes which use the chemicals and materials. This analysis will be conducted by personnel assigned to San Antonio Air Logistics Center, Materials Engineering Section, of the Technology and Industrial Support Directorate (SA-ALC/TIESM). They have been tasked to provide alternatives to chemicals, materials, and processes which are identified by the program office.

For the F-5, the next step was to incorporate the results of the analysis and ranking of hazards into a Pollution Prevention Plan for use by the F-5 Program Director. A technical team identified within the F-5 program office will be tasked by the program manager with verifying that the identified alternative chemical, material, or process will not adversely effect system performance when used in the specific application which was being analyzed. Once the alternative has been approved, the team will be responsible for appropriate changes to the support system, which will include, but not be limited to, updating the technical order system, updating the supply system, and updating the management information system.

There were three major goals for this thesis:

1. To conduct a hazardous materials analysis of the technical documentation available for the F-5A aircraft.

2. To develop a pollution prevention program for the Air Force F-5 Program Director.

3. To develop a generic approach for developing similar pollution prevention programs for the other aircraft managed by the Proven Aircraft Division.

Thesis Scope

This thesis is important because it supports the goals of at least two separate programs: pollution prevention, our national policy to protect the environment, and security

assistance, our national policy to support our allies, permit the sale of the military aircraft, and insure the logistics support of the aircraft thereafter. (69)

In his paper on "DoD Environmental Requirements and Priorities", Thomas E. Baca, Deputy Assistant Secretary of Defense (Environment) paraphrases Secretary Cheney as saying:

> *Defense and the environment is not an either/or proposition. To choose between them is impossible in this real world of serious defense threats and genuine environmental concerns. The real choice is whether we are going to build a new environmental ethic into the daily business of defense - make good environmental actions a part of our working concerns, from planning, to acquisitions to management. (8:335)*

II. Background Review

National Policy

In 1990, President Bush stated:

> *Environmental programs that focus on the end of the pipe or the top of the stack, on cleaning up after the damage is done, are no longer adequate. We need new policies, technologies, and processes that prevent or minimize pollution - that stop it from being created in the first place.* (41:619)

An EPA definition of pollution prevention is *the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect natural resources through conservation or more efficient use.* (41:619)

The federal government has the capability to significantly influence both the development and the implementation of pollution prevention programs and technology. It does this in three ways. First, the government creates laws and regulations which effect everyone from private individuals to international businesses owned by U.S. citizens. Next, the government operates a variety of manufacturing facilities and enterprises. These include the government-owned-contractor-operated (GOCO) manufacturing plants, as well as military installations, office complexes, and national parks and recreation facilities. Last, the government is a major consumer of manufactured goods, services, and raw materials. In all of these cases, the government has the opportunity to require the reduction of pollution, the minimization of hazardous waste, and the development of environmentally safe products and technologies. (41:621; 82:181-188)

Federal Law

In the past, the Department of Defense frequently sited the legal concept of sovereign immunity when dealing with environmental laws and regulations. Sovereign immunity provides the federal government with protection from lawsuits or other legal

actions brought against it by other government activities. Between 1983 and 1989, nine Army government-owned, contractor-operated facilities were levied fines of more that $1.5 million dollars for failing to comply with environmental legislation (85:14). In addition, sovereign immunity was thought to include government employees. That changed when three supervisors at Aberdeen Proving Grounds were the first government employees to be tried and convicted for ignoring environmental laws (85:133). *Prison terms for violating these statutes* (federal and state) *range from six months to 15 years* (29:7). The message is clear. Environmental laws apply to everyone.

The Pollution Prevention Act of 1990. The Pollution Prevention Act of 1990 is a statement of national pollution policy. In it, Congress declares it to be the national policy of the United States that pollution should be prevented or reduced at the source whenever feasible (41:622; 94). The Act specifically tasks the EPA to develop, identify, facilitate, and coordinate efforts to comply with its provisions. (41:622; 94)

The Clean Air Act Amendment of 1990. The 1970 Clean Air Act was amended in 1990 to address the most critical of the air pollution problems, including toxic air emissions, acid rain, smog, and stratospheric ozone depletion. Emphasis in the amendment was on pollution prevention - a change from previous documents. Of particular importance to the Department of Defense, the Amendment called for a phased reduction on chlorofluorocarbons (CFCs) and halons beginning in 1992. (41:622; 78:98-108)

U.S. Environmental Protection Agency Policy. In keeping with the trend towards emphasis on prevention rather than clean-up (92:112-115), the U. S. Environmental Protection Agency (EPA) published its own Pollution Prevention Policy in 1989. Then in February of 1991, is also issued a Pollution Prevention Strategy which provided an expanded version of its position and objectives. A major part of that strategy

was the development of a program that could achieve specific pollution prevention objectives in a reasonable amount of time. This strategy is called the 33/50 Program.

The 33/50 Program. The Office of Toxic Substances within the EPA is responsible for administering the 33/50 Program. The program itself is a voluntary pollution prevention initiative which builds on the EPA's policies and objectives. The program expects to reduce, by 50%, the release of 17 targeted chemicals and chemical compounds from a total of 1.4 billion pounds in 1988 to 700 million pounds in 1995. (41:625) The program has three goals: 1. to reduce national environmental releases of the EPA 17 to 50% of the 1988 levels by 1995; 2. to encourage pollution prevention rather than end-of-pipe treatment to accomplish this goal; and 3. to help foster a pollution prevention ethic in business (98:2).

International Agreements.

The last five years has seen an increased emphasis on a global approach to environmental concerns. The U.S. government has participated in both of the major world-wide conferences which have been held.

The Montreal Protocols. In September 1987, representatives from forty-seven countries met to discuss their concern over the depletion of the ozone layer. The result was a document called the Montreal Protocol on Substances that Deplete the Ozone Layer. The protocol became effective 1 January 1989 for the initial 28 nations who signed the agreement. By this agreement, the consumption level of selected ozone depleters and halons was frozen at 1986 levels, and the countries further agreed to a 50% reduction in consumption by 1999. (52:41). Former President Bush moved the phase out of U.S. production of ODC from 2000 to 1993 in February, 1992. Then, in November, 1992, *the United Nations ratified the Montreal Protocol Treaty (Copenhagen amendments) which prohibits ODC halon/solvent production in 1994 and chlorofluorocarbon production in 1995* (19:A-13). Members of the European Community have already accelerated their

phaseout schedule for some compounds. Most chlorofluorocarbons must be cut 75% from each country's 1986 baseline by 1 January 1994, and completely phased out by 1995. (6:22)

The United Nations Conference on Environment and Development. The Earth Summit in Rio de Janeiro took place in early June, 1992, bringing together over 150 nations, 1400 non governmental organizations, and 8,000 journalists (43:1). The primary achievement of the Rio Summit is the global warming treaty, which incorporates into international law the idea that nations have agreed to take global environmental issues into consideration while they are making domestic economic decisions (38:33). Many of the nations that were represented at the conference were willing to propose specific timetables for the voluntary reduction of carbon dioxide emissions (3:1503). In addition, 178 nations agreed on a document which calls for environmentally sound development policies in underdeveloped countries (10:46). For those same countries, the concept of sustainable development does not imply that economic growth should not take place. Rather it implies that growth should not adversely effect the ecosystem (11:869-870; 38:33; 89:1075). Whether the conference was the success it was hoped to be, or not, it *must be judged within the context of a process of increasing attention, sophistication, and effectiveness in the management of environment and development issues* (43:1). On this criteria alone, it must be concluded a resounding success.

Air Force Environmental Policy

In October 1986, The Scientific Advisory Board (SAB) identified the need to consider hazardous materials in the weapons system acquisition process (WSAP). They also found that the mechanism to identify, manage, and control hazardous materials in the WSAP did not exist. In June 1987, Headquarters, USAF tasked Air Force Systems Command (AFSC) to develop proposed actions and initiatives necessary to implement the Scientific Advisory Board recommendations. In August 1987, the Deputy Commander for AFSC

(AFSC/CV) briefed USAF/LE concurring with the SAB report, and advising USAF that they had organized a Hazardous Materials Working Group (HMWG) at AFSC. AFSC/CV approved a plan to introduce biotechnical expertise early in the acquisition process, which was developed by the HMWG in December, 1987. In February 1988, the vice-commander of AFSC asked the commander of ASD to form a working group at the division level to parallel the AFSC group. In addition, a General Officers Steering Committee was formed. The ASD group was called the ASD Working Group: SAB Report on Hazardous Materials. Responsibility to chair the group was given to ASD/DE, (Civil Engineering), Mr. Eric Stevens. All ASD two letter organizations were asked to send members. The ASD Working Group initially concluded that management of hazardous materials should reside in DE. As a result, Mr. Stevens asked for, and received, two additional slots in his organization. He and a number of other group members visited various systems program offices (SPOs) to discuss the issue. The General Officer Steering Committee met, with specific direction to study the issue and provide long term direction. A primary focus of the group was to use Logistics Support Analysis (LSA) as the management vehicle for hazardous materials. In October, 1988, information from all of the groups was forwarded to AFSC, as they deliberated how to continue the efforts. As a result, AFSC/MO (Manpower) became the OPR to look at resources. In January 1989, Maj Gen Doppelt again discussed the issue with AFSC/CV, who in February directed the formation of another group - to be called the Acquisition Management of Hazardous Materials Working Group. Their primary responsibilities were to: 1. detail planned actions, 2. assign OPRs, and 3. establish milestones for implementation of a hazard materials management plan. The working group completed an initial action plan which was approved by AFSC/CV on 27 February 1989. In March, Col Coughlin (HSD/EV - Human Systems Division, Environmental) presented the HSD view to the AFSC/AFLC Commanders Conference. After that meeting, Maj Gen Doppelt personally

briefed Gen Randolph. As a result of that discussion, Gen Randolph directed the initiation of an HSD task force at Brooks AFB, TX to manage hazardous materials. Col Bill Smith, HSD/SD, formerly AFSC/SDT, was in charge, and program initiation was set for 1 October 1989. Also in late 1989, AFSC contracted with the MITRE Corporation to perform a preliminary evaluation of current status of hazmat management in the Air Force (57:3). The result was a series of documents which described these issues in detail (60; 61; 62; 63; 63; 64; 65; 66; 67).

The ASD SAB Working Group had met in early summer, 1989 to vote on which ASD organization should own the ASD Hazardous Material Management Organization. The three organizations being considered were ASD/EN (Engineering), ASD/DE (Civil Engineering), and ASD/SE (Safety). The ASD SAB Working Group voted for ASD/SE, and the ASD Hazardous Material Management task force (ASD/SEH), headed by Lt. Col. Harvey Clewell was established there. In December, 1989, Maj Robert Elves took over the office, and in mid 1991, he was joined by Capt Michael Boucher and Capt William Shelton. Their Hazardous Materials Management office encouraged the initiation of hazmat working groups in key ASD program offices, and viable programs were started for the B-2, F-22, and others. (91:1-5)

Emphasis in program offices was increased with release, in February 1991, of DoDI 5000.2, Part 6, Section I: System Safety, Health Hazards, and Environmental Impact. It required each acquisition program to identify and manage potential problems and alternatives (35: p 6-I-1 & 6-I-2). There was concern that program managers would not manage this area appropriately because there were no reporting mechanisms (17:9), however, that problem was laid to rest with the implementation of AF Supplement 1 to DoDI 5000.2 which required formal reporting at milestone decisions.

Another significant event occurred 26 - 29 May 1992. AFMC/EN sponsored an Ozone Layer Depelting Substances (OLDS) Elimination Workshop at Wright-Patterson AFB.

The workshop brought together over 122 participants from every part of the DoD. The objective of the workshop was to make available information on OLDS elimination efforts throughout AFMC and the DoD. (77)

After the release of the Pollution Prevention Program Action Plan (described below) in January, 1993, HQ AFMC *formed a pollution prevention team tasked with implementing the program and spreading the philosophy throughout the Command (18:7). The 22-member Integrated Product Team is comprised of representatives from Civil Engineering (CE), Logistics (LG), Science and Technology (ST), Requirements (XR), Engineering and Technical Management (EN) Safety (SE), Command Surgeon (SG), and Contracting (PK), as well as the Aeronautical Systems Center (18:7).*

Pollution Prevention Program Action Plan. On 13 November, 1991, Air Force Secretary Dr. Rice and Chief of Staff General McPeak released a draft memorandum which stated the Air Force policy on pollution prevention.

> *The Air Force is committed to preventing future pollution by reducing use of hazardous materials and releases of pollutants into the environment to as near zero as feasible. The key is to move quickly away from dependence on hazardous materials. We must mobilize our whole team and find ways to move faster. (99)*

Air Force Pollution Prevention Program - Action Memorandum. The final version of the Pollution Prevention Program Action Plan was issued as the Air Force Pollution Prevention Program - Action Memorandum, on 7 January 1993. The wording of the final version was even stronger.

> *The Air Force is committed to environmental leadership. Our goal is to prevent future pollution by reducing the use of hazardous materials and releases of pollutants into the environment to as near zero as feasible. To achieve this, we must quickly move away from dependence on hazardous materials, actively reduce our waste streams, reuse the wastes we do generate, recycle what we cannot reuse, and expand purchasing programs*

for recycled products. To succeed we must mobilize our whole team and find ways to move faster. (26:1)

The Plan included six objectives which were to guide Air Force actions. Of particular importance to this research effort is Objective 2:

> *Reduce the use of hazardous materials in existing (deployed) weapons systems by finding less hazardous materials and processes and integrating them into Technical Orders, Military Specifications and Military Standards. (26:2)*

AF/LG was identified as the Office of Primary Responsibility (OPR), and SAF/MI, AF/CE, AF/SG, AF/XO, and Air Force Material Command (AFMC) were listed as Offices of Collateral Responsibility (OCR).

The Memorandum included a number of sub-objectives which are germane to this thesis. They include a commitment to *institutionalize pollution prevention including hazardous materials minimization and management* (26:2), *implement proactive procurement policies and practices* (26:2), and implement *a hazardous material identification and tracking capability at the Air Logistics Centers* (26:3).

Particularly important was a sub-objective which required: *By the end of 1993 prioritize the hazardous material TOs, MILSPECS, and MILSTDS for existing weapons systems for review. By the end of 1995 review the worst 25% and by the end of 2000 complete the review for existing weapons systems* (26:3). The initial review of technical orders, and the exhaustive review of a sample of technical orders performed during the conduct of this thesis were the first step towards compliance with this objective.

Air Force Ban on Purchases of Ozone Depleting Chemicals - Action Memorandum. On the same day that the Air Force issued its Pollution Prevention Program, it also released the Air Force Ban on Purchases of Ozone Depleting Chemicals (ODCs) - Action Memorandum. The memorandum implemented the National Defense Authorization Act for Fiscal Year 1993, Title III, Section 326, Public Law 102-484 and the 11 August 1992 policy on ODCs issued by the Under Secretary of Defense for Acquisition, by instituting

an Air Force policy governing the purchase, use and management of controlled ODCs. (24:0) It had already defined the ODC problem, divided the controlled chemicals into Classes and Groups, and described the quantities of each chemical which could be legally manufactured (27:2, Annex 2).

The rationale for this step was significant. The memorandum stated:

> *We are taking this action for several reasons. Recent scientific data shows the earth's ozone layer is being destroyed far more rapidly than we previously believed, and for the first time, ODCs in the atmosphere threaten to deplete the ozone layer over populated areas of the world. Last month (December, 1992), the United Nations agreed to end chlorofluorocarbon (CFC) production by 1995 and halon production by 1994 at the Montreal Protocol renegotiations. This will result in a global ODC production ban. Additionally, declining market demand will likely create supply problems before the production phaseout date, jeopardizing missions dependent on a continued supply of these substances. (20:0)*

The memorandum allowed waivers, but particularly noted that waivers permitted under this policy were only to be used to extend the time necessary to develop and implement alternatives, not to permit program managers to circumvent the intent of the law. It also stated that effective 1 April 1994, the Air Force would no longer purchase ODC solvents, and their associated equipment. All specifications and standards requiring ODC use would be tailored to allow non-ODC alternatives. And AFMC would review all Air Force Technical Orders to identify ODC use and provide their lists to program managers and directors to have them revised. This activity also has a goal of 1 April 1994. (20:5)

The most immediately significant requirement in the memorandum implemented Public Law 102-484, National Defense Authorization Act for FY 93, Section 326. It said: *No contract awarded after June 1, 1993 shall include a requirement to use ODCs or any requirement that can be met only through the use of ODCs, without approval of SAF/AQ* (20:5). This requirement essentially shut-down contracting for the Air Force on 1 June 1993. By the end of July, 1993, only one waiver has been approved. Resolution of this

issue has been the top priority in the acquisition community. Further amplification of this policy was provided in two additional documents, with more expected. The first, dated 21 May 1993 was a memorandum for directors of defense agencies on the subject of Elimination of Ozone-Depleting Substances (32). It identified the interim rule which amended the Defense Federal Acquisition Regulation (DFAR), and it described the criteria to be used to determine if a particular contract awarded before 1 June 1993 would "trigger" the rule. The second document was an Interim Air Force Contracting Policy for Elimination of Class I Ozone Depleting Substances, and was dated 26 May 1993 (23). It emphasized that Air Force policy on the elimination of Class I ozone depleting substances *is more restrictive than that required by the statute or the DFARS language*. Contracting issues will continue to be a significant problem to the DoD (90:13-15).

This was the status of the Air Force pollution prevention program by the middle of 1993.

National Security

Although adequate efforts to institutionalize pollution prevention in the Air Force are underway, there still remains the global impact of the operation and maintenance of American weapon systems which have been sold to our allies under the various security assistance programs. In addition to our own effort to provide national security, the United States is concerned with the support and encouragement of our allies. Our concern should include a responsibility to identify for elimination or minimization those hazardous chemicals and materials which we have required in the maintenance and operation of security assistance weapon systems, and which we have targeted for elimination from our own current weapon system inventory. (13:Ch 6)

Foreign Policy. A primary means of carrying out foreign and national security policy has been the sale or transfer of weapons systems, together with their logistics support,

training, and various other services to our allies. (34) The term that is used to describe the activities carried out under this concept is "security assistance".

Security Assistance. Security Assistance is defined as:

> *Groups of programs authorized by the Foreign Assistance Act of 1961, as amended, and the Arms Export Control Act (ACE) of 1976, as amended, and other related statutes by which the United States provides defense articles, military training, and other defense related services, by grant, loan, credit, or cash sales in furtherance of national policies and objectives. (16:33)*

Included under the umbrella of Security Assistance are six major program components: 1. Foreign Military Sales (FMS) and Foreign Military Construction Sales Program, 2. Foreign Military Financing Program, 3. Direct commercial sales under the AECA, 4. International Military Education and Training, 5. The Economic Support Fund, and 6. Peacekeeping Operations. Foreign Military Sales, Foreign Military Construction Sales, and direct commercial sales are funded by the gaining country. All of the other programs are funded using United States government funds. The Defense Institute of Security Assistance Management has pointed out, in its management text, that *Security Assistance is not a philanthropic effort. The United States offers security assistance to strengthen the national security of friendly nations, and to support existing or prospective democratic institutions and market-oriented economies (16:5).*

The Air Force Security Assistance Program. The Office of the Secretary of the Air Force, Deputy Under Secretary for International Affairs is the focal point for the implementation and management of security assistance for the Air Force. Management responsibility for particular items can be delegated to the appropriate major command. In particular, follow-on support for weapon systems is managed through the Air Force Security Assistance Center at Wright-Patterson AFB, Ohio. (16:93)

International Logistics. International logistics is related to security assistance, but does not include the aspects of the Economic Support Fund, Peacekeeping Operations, and International Military Education and Training. International logistics is a way to provide military logistic support to countries participating in security assistance programs. (16:35)

Total Package Approach. One reason for the success of the U.S. security assistance program is a concept called the total package approach. The total package approach is a means to provide the participating country with all of the relevant information needed to plan and to obtain the support items and services which are necessary for acquisition and operation of the chosen weapon system. (16:144)

San Antonio Air Logistics Center Proven Aircraft Division. Personnel assigned to San Antonio Air Logistics Center Proven Aircraft Division are the System Program Managers for 29 weapons systems which are no longer in the active Air Force inventory, but which have been provided to foreign countries. Proven Aircraft personnel maintain liaison with the supported countries, provide supply support, help identify existing and incipient supply support problems, and coordinate resolution of such problems.

F-5 Program. The primary focus of Proven Aircraft is the F-5 weapon system. (Figure 1) The F-5 Technical Coordination Group (TCG) and Systems Program Management Branch (SA-ALC/LAVF) is the focal point for international logistics support and management of the F-5 aircraft worldwide. Their Branch Chief is, in effect, the F-5 Program Director. The TCG also serves as a point of contact and central source of information on F-5 technical and logistics issues and concerns. The F-5 Technical Coordination Group is contracted by the 24 member countries (Table 1) to provide them with the expertise and information necessary to operate and maintain the F-5.

In the fall each year, the F-5 TCG sponsors a world-wide review. The review has proven to be an effective forum to discuss pollution prevention and hazardous waste minimization efforts.

Table 1. F-5 Technical Coordination Program Member Countries.

Bahrain	Jordan	Norway	Taiwan
Brazil	Kenya	Philippines	Thailand
Canada	Korea	Saudi Arabia	Tunisia
Greece	Malaysia	Singapore	Turkey
Honduras	Mexico	Spain	Venezuela
Indonesia	Morocco	Switzerland	Chile

The TCG supports all models of F-5 aircraft, but primarily the F-5A, F-5B, F-5E, and F-5F. The F-5 Tiger aircraft (72:I-1) is a supersonic tactical fighter aircraft, manufactured by Northrop, and designed for high performance in an air superiority role. It is also used in an air-to-ground, and a training role. Reliability, maintainability, and operational flexibility were emphasized in the original design with the intent to field a system which had a low initial cost, low operating cost, and minimum logistics requirements. At the same time, the system was easy to maintain, quick to "turnaround" in combat, and capable of sustaining high sortie and readiness rates. (72:1-2) At one time, there were more than 2500 F-5 aircraft flying in 30 countries around the world (72:I-1).

III. Methodology

Identification of Problem Processes, Chemicals, and Materials.

The primary focus of this phase of the actual F-5 Pollution Prevention Program is the identification of problem processes, chemicals, and materials. The easiest way to identify problems, from the point-of-view of a Program Office, is to let a contract with the prime contractor, to review TOs, locate occurrances of ODCs or hazmats, and suggest alternatives. This is also the most expensive way to identify problems. At a lower level of cost and activity, automation of TOs, and automated word search of TOs are a possibility. The automation efforts of AFMC/ENX and SA-ALC/TIESM, discussed in the section on automation, are examples. At the lowest level is a by-hand search of the TOs to identify ODCs and hazmats. While not expensive in terms of contrac t funding, it is still very expensive in terms of time and effort. The individual reviewing the TO must understand both the context in which the chemical, material, or process occurs and the ODC and hazmat search criteria. A limited by-hand search was conducted for this thesis.

Initial Technical Order Identification and Detailed Review. Four F-5A technical orders were initially selected as having the greatest possibility of having numerous examples of ODCs and hazmats. The TOs which were reviewed included *Aircraft General (1F-5A-2-1, through Change 14), Ground Handling, Servicing, and Airframe Maintenance* (1F-5A-2-2, through Change33), *Pneudraulic Systems* (1F-5A-2-4, through Change 19), and *Powerplant* (1F-5A-2-6, through Change 15). The TOs were selected (27) based on the author's aircraft maintenance experience, and after discussion with maintenance specialists.

The TO analysis was initiated in December, 1992, and completed prior to the author's trip to Kelly AFB, Texas, the last week of April, and the first week of May, 1993. Reviewing a 200 to 300 page TO and highlighting every occurrance of a chemical,

material or process took about eight hours to accomplish. As an additional exercise, during the trip to Kelly AFB, the author reviewed the "B" model version of the *Powerplant* TO: 1F-5B-2-6. Using the "A" model spreadsheet, described below, the author was able to conduct the "B" version review in one and one-half hours.

SA-ALC/LAV at Kelly AFB maintains the F-5 TO library. While at Kelly AFB, the author also did a "quick look" review of the first 181 TOs in the F-5 library (24). The goal was to rapidly identify those TOs that did not require review, those that required some review, and those that required detailed review. Of the 181 TOs, 116 did not require additional analysis. 65 TOs, including the five TOs that had been reviewed by that time, required some level of detailed analysis . (See Appendix B in the F-5 Pollution Prevention Plan, Appendix A)

Creation of Spreadsheet Data Base. Once the chemicals, and materials were highlighted in the text, the next step was to put them in a form that would enable the Pollution Prevention Program Manager (PPPM) to sort, review, and manage them. The author chose to use an Excell spreadsheet to accomplish this task. The author created a double-wide spreadsheet that contained the following fields: chemical, known as, commercial name, military name, reference, Federal Stock Number (FSN), page, line, current practice is to use, non-hazardous alternative, type of operation, crew size, quantity, time, individual risk, environmental risk, and comments. Some of the information is readily available from the text of the TO. Some information is implied (e.g. type of operation). A lot of the information is not easily obtained, and will probably be added-to and updated over a period of time. Eventually actual substitutes will be added to the data providing an audit trail of information on the elimination or minimization effort that was undertaken in each instance. The actual spreadsheets for the first five TOs have been included in Appendix B.

Sort of Data Base by Management Category. After all of the available information was loaded into the spreadsheet data base, the data was sorted based on the author's management criteria. Five management criteria were identified: special management, operational management, tactical management, strategic management, and minimal management. Special management included compound hazards, for example, materials or chemicals which were both nuclear hazards and hazardous materials; or explosive hazards and hazardous materials. At this time, no compound hazards have been identified for the F-5. The operational management category included materials and chemicals which have been identified as significant individual or environmental risks, or which require special emphasis because of laws, treaties, and policies. This category presently includes ozone depleting chemicals and the EPA 17 (Table 2) industrial toxics (98).

Table 2. Environmental Protection Agency List of 17 Industrial Toxics

1. Benzene	7. Lead & Lead Compounds	13. Tetrachloroethylene
2. Cadmium & Cadmium Compounds	8. Mercury & Mercury Compounds	14. Toluene
3. Carbon Tetrachloride	9. Methylene Chloride	15. 1,1,1, - Trichloroethane
4. Chloroform	10. Methyl Ethyl Ketone	16. Trichloroethylene
5. Chromium & Chromium Compounds	11. Methyl Isobutyl Ketone	17. Xylenes
6. Cyanide & Cyanide Compounds	12. Nickel & Nickel Compounds	

Tactical management includes materials and chemicals which have been identified as a moderate individual or environmental risk, or which are projected to be a future problem (17:10). As an example, volatile organic compounds (VOC) have been implicated in the development of smog. In the near future, the EPA is expected to target stationary sources of VOCs in an attempt to reduce their VOC emissions. A primary source of VOCs for the DoD are paints. Strategic management was set up for materials and chemicals which have a low, but identifiable individual or environmental risk. As an example of this management category, some lubricating oil may contain tricresyl phosphate, a readily absorbed poisonous substance. Minimum management is the last category. It includes materials and chemicals which are identified in F-5 aircraft TOs but which are not considered hazardous materials at this time. They include such things as fuels, hydraulic fluid, and lubricating oil. These management categories were used to produce the operational and tactical management sections of the 30 June 1993 F-5 Pollution Prevention Management Plan. As the program progresses, additional rankings within category based on actual risk (15; 44:451-464; 53) will be developed.

Creation of the F-5 Pollution Prevention Program.

In order to create a pollution prevention program, it is necessary to understand that the goal is prevention of pollution at its sourse. The first task is to identify a particular chemical, material, or process as a potential pollutant, then eliminate or minimize its occurrance in the operation and maintenance of weapon systems. (46; 47; 48; 68; 100) *Pollution prevention is a total systems program that includes not only waste generation, but also early systems requirements planning and refinement, materials selection, process development, materials acquisition, handling and use of materials, production activities, process management, waste management, and disposal* (19:1(Summary)) Defining the term "hazardous material" is a somewhat more involved process because there is no simple answer. The definition of hazardous material varies depending on the

federal environmental legislation in which it is found. The DoD defines a hazardous material as:

> *Anything that due to its chemical, physical, or biological nature causes safety, public health, or environmental concerns that result in an elevated level of effort to manage it.* (35)

Strategy for Management. The F-5 Pollution Prevention (PP) Program Manager (PM) is responsible for planning, coordinating, and documenting efforts towards minimization or elimination of chemicals, materials, and processes which are hazardous to individuals or the environment. The F-5 Program Director is informed or briefed on the problem areas, the proposed alternatives, and the status of the efforts. The Director is then responsible for making an informed decision, and initiating efforts to obtain required resources. Once an acceptable alternative is agreed upon, the Integrated Product Team, or other individuals appointed by the Program Director, implement the change in the system. Results are forwarded to the F-5 PP Program Manager for inclusion in the next quarterly report.

F-5 Pollution Prevention Plan The F-5 Pollution Prevention (PP) Plan is intended as a tool used to inform the F-5 Program Manager of the extent of the problem, document on-going efforts, and report completed actions. Lt Col Clewell has pointed out that such a plan is the key to tying the overall pollution prevention effort together (14:unnumbered). The full F-5 PP Plan will be sent to the Program Manager quarterly, with monthly updates to document newly identified ODCs or EPA 17 toxic materials during the identification phase of the program. Eventually all of the ODCs and EPA 17 materials will be identified, and alternatives will have started to be identified for all of them. At that point, a new round of identification of general hazmats will be started. In addition, as additional problems are uncovered, new criteria for new hazmats will be released to the DoD for identification and resolution. In fact, in further iterations, alternatives which were

identified in this round of activity could be identified as a problem for future efforts (104:1055-1061). The initial F-5 PP Plan created as a result of this thesis was sent to the Program Director on 30 June 1993, and is included as Appendix A. The PP Plan will be both a repository of information documenting pollution prevention management actions and an audit trail of how the actions were considered and implemented.

Metrics will be included in the plan when appropriate, to enable the Program Director *to measure program health and effectiveness as we implement our strategy to help reduce and prevent impacts to human health and the environment (22:2).* Tools for measuring waste reduction (30; 31) are important management considerations.

Integrated Product Team. To continue the efforts started in this thesis, an integrated product team (IPT) was identified in the Proven Aircraft Division (SA-ALC/LAV). The team, headed by Mr. John Rich, is expected to work the day-to-day issues that arise as a result of this effort. They will work with the individual assigned to support LAV to identify potential alternatives, and to determine if the proposed solution will be acceptable in the particular application under consideration. Once concurrence of the engineering and logistics members of the team is obtained, the change will be implemented. Some of the activities that should occur at that point are identified in more detail in the IDEFo systems analysis described below, and include updating the technical order system (28), the supply system, any applicable data management or management information system, and any other appropriate function or organization. Details on how the information will be presented to the foreign governments who own and fly F-5 aircraft have not been identified.

Alternatives. The Materials Engineering Section, Specialized Engineering Branch, Engineering Division, of the Technology and Industrial Support Directorate (SA-ALC/ TIESM) is responsible for identifying alternatives to identified hazardous materials, chemicals and processes. Ms Catherine Gastauer is the focal point for all Proven Aircraft

activities. The Section is small - only five people at present, and, since they are also responsible for identifying alternatives for all of the other programs at their ALC, they have determined that they will contract-out a major portion of their documentation review, hazmat and ODC identification, and proposal of alternatives activities. This same organization was responsible for the development of an automated technical order review process for hazmat identification called TORP: Technical Order Review Program. TORP will be discussed in more detail in the section on automation issues. Two categories of replacement alternatives can be defined: simple and complex. An example of a simple replacement alternative is the replacement of solvent P-D-680 Type II, when used on machined aluminum, with P-D-680 Type III. There is very little difference between the two items, and minimal impact on performance, life cycle cost, retrofitting, and testing. A complex replacement alternative, on the other hand, has significant impact on all of these areas. A good example is identification of an appropriate alternative for halon. Alternatives exist, but each pay a penalty in performance, weight, volumn, and retrofit costs, at the very least.

Decision Implementation. Once the potential alternatives have been identified by the Materials Engineering Section, the information is forwarded back to the Proven Aircraft Division (most likely, to the IPT mentioned previously) for review by their technical staff to ensure that the particular alternatives are acceptable in the application in question. In cases where multiple alternatives are acceptable, the technical staff may suggest a particular alternative, using internally developed criteria. At present, there are very few tools available to help the technical staff or the program manager make such a decision, although there are a few helpful books which attempt to address this point (13; 15; 44; 76; 103). In the past, such decisions in the Air Force may have been based on lowest unit cost. Life cycle costs of hazardous materials are much more complex to analyze. The Human Systems Center, Pollution Prevention Office (HSC/PP) has been responsible for

the development of a Hazardous Materials Life Cycle Cost model (48). The model describes, for a service specific module, the costs associated with a particular chemical or material in terms of the sum of a series of separate costs. The cost categories include: procurement, personal protection, management, handling, potential legal/ environmental liability, medical, and disposal. The manual states that:

> *The procurement cost element includes the actual purchase price of the hazardous materials plus the cost of transportation to the site of use, whether it be depot or operating location. The personal protection cost element consists of three sub-elements: the cost of the personal protection equipment, including maintenance and support, the cost of inefficiency as a result of wearing the equipment, and the cost of dispensing the equipment. The cost of handling is attributed to two sub-elements: the cost of subdividing, labeling, and distributing the materials, and the cost of lost productivity due to the controls placed on the hazardous materials and their distribution. The potential legal/environmental liability cost element covers potential liability for five components: toxic torts, regulatory authority correspondence, real property damage, contaminated water treatment, and natural resource damage. Management includes those functions necessary to maintain oversight of the hazardous materials at the locations where they are used. This is primarily a labor cost. The medical cost element consists of four subelements: occupational physical examinations, including lost time while the physical is administered; medical surveillance; lost time due to illness/injury as a result of hazardous materials; and industrial hygiene surveys. Lastly, the disposal cost element encompasses the cost to operate an Industrial Wastewater Treatment Plant (IWTP), where applicable; waste collection and handling; contractor disposal; and hazardous waster analysis and classification. (48:p2-2)*

While this could be an acceptable way to differentiate costs, not all of the basic units of cost information are collected and available. However, as more people reach the point in their program where they must make this type of decision, there will be a greater demand for tools and data to facilitate the decision making process.

Updates and Revisions. The F-5 Pollution Prevention Program is an effort which will continue during the life of the F-5 weapon system. Replacement for an existing problem process, chemical or material is a "best guess" at this point in time. The replacement chemical, material or process could itself be identified as a problem in the future as identification criteria and national interest changes. Updates and revisions to the F-5 PPM Plan will occur frequently. At present, the F-5 PP Management Plan (Appendix A) is being produced quarterly, with potential monthly updates to the problem identification section.

Systems Analysis of F-5 HAZMAT Minimization Process.

To understand how the F-5 PPM Program fits into the overall Air Force PPM Program, the author conducted an systems analysis of the AF PPM Program process. The analysis was produced using IDEFo as the modeling language. IDEFo is described in greater detail in the following section. The F-5 PPM Process is described within the AF context, and from the point-of-view of the F-5 PPP Manager.

IDEFo. IDEFo (read as IDEF sub zero) is a *technique that enables people to understand complex systems in a complete and precise manner, and enables them to communicate their understanding (87:pA-2).* Applying the IDEFo methodology allows the investigator to model a "top down" look at the system in question. The charts are arranged in a hierarchy, starting with the top level chart (Figure 2). The chart is arranged so that each function box can have inputs (from the left), outputs (to the right), constraints (from the top), and mechanisms to accomplish the function (from the bottom). Each box on each chart can then be further described on a subsequent ("child") chart. Examples of such functional descriptions can be found in a number of sources (39; 45; 86; 87). The set of IDEFo charts created for this thesis are included as Figures 2 through 7.

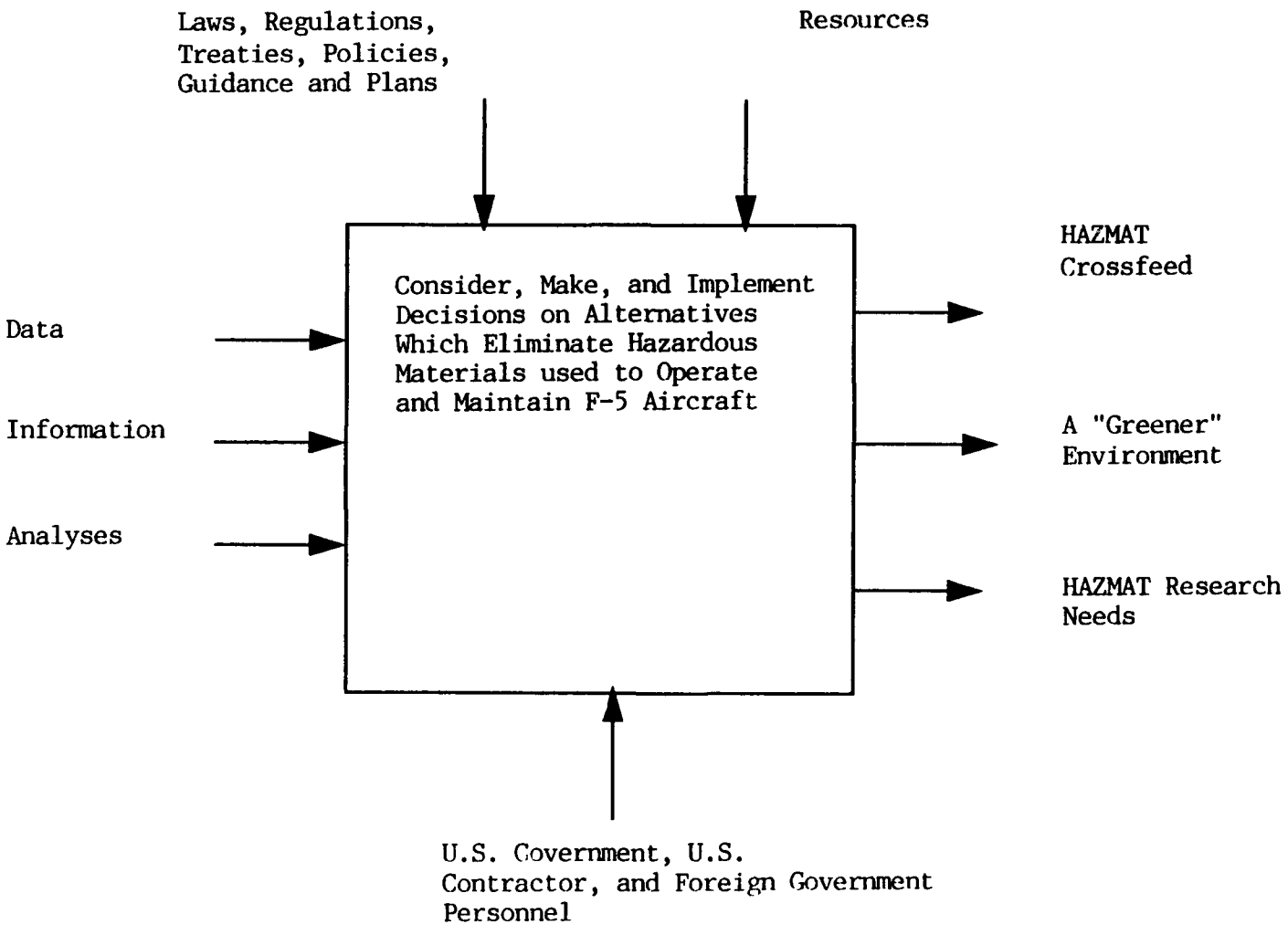

Figure 2. The Goal: Consider, Make and Implement Decisions (A-0)

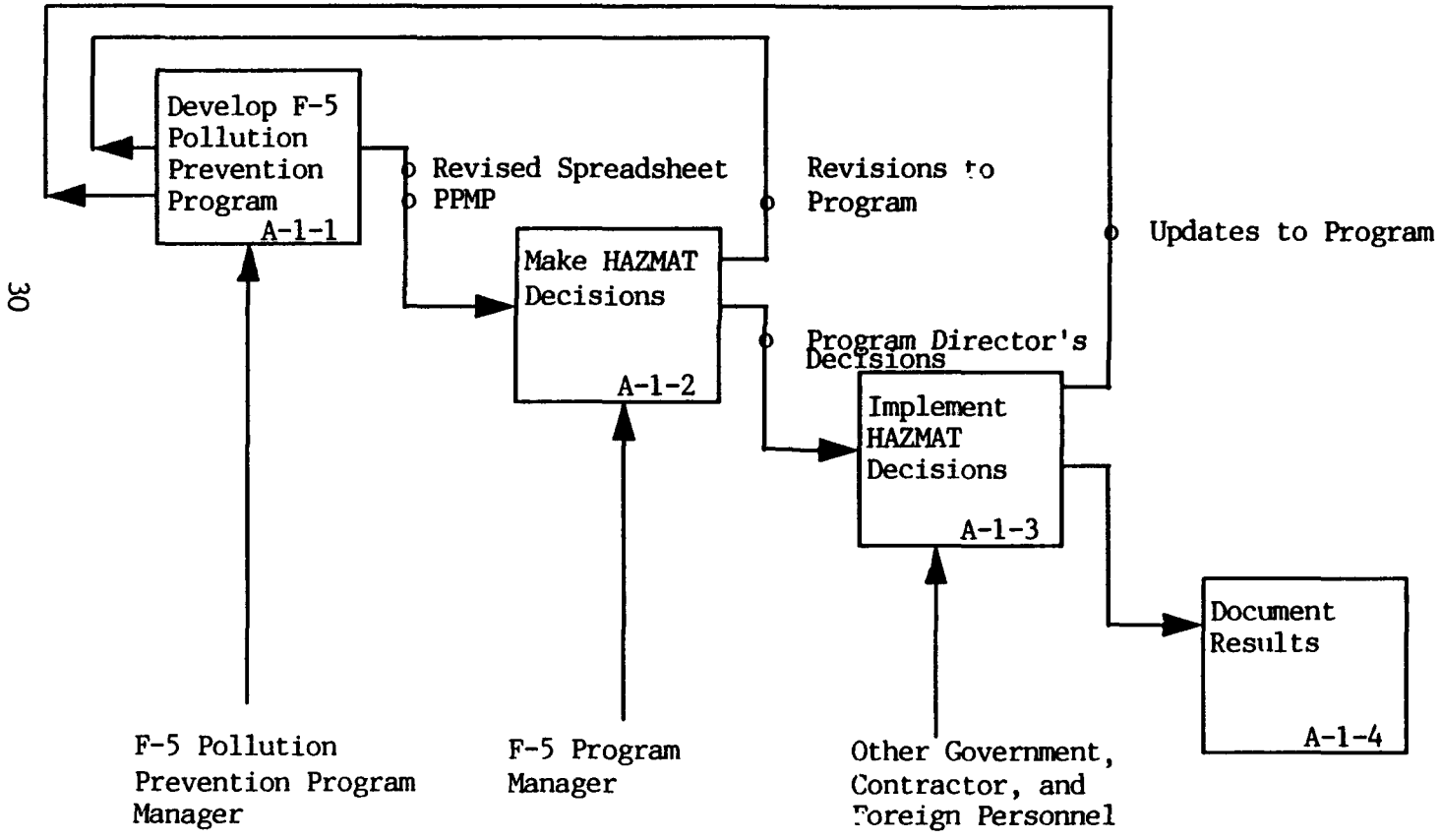

Figure 3. The F-5 Pollution Prevention Management Process (A-1)

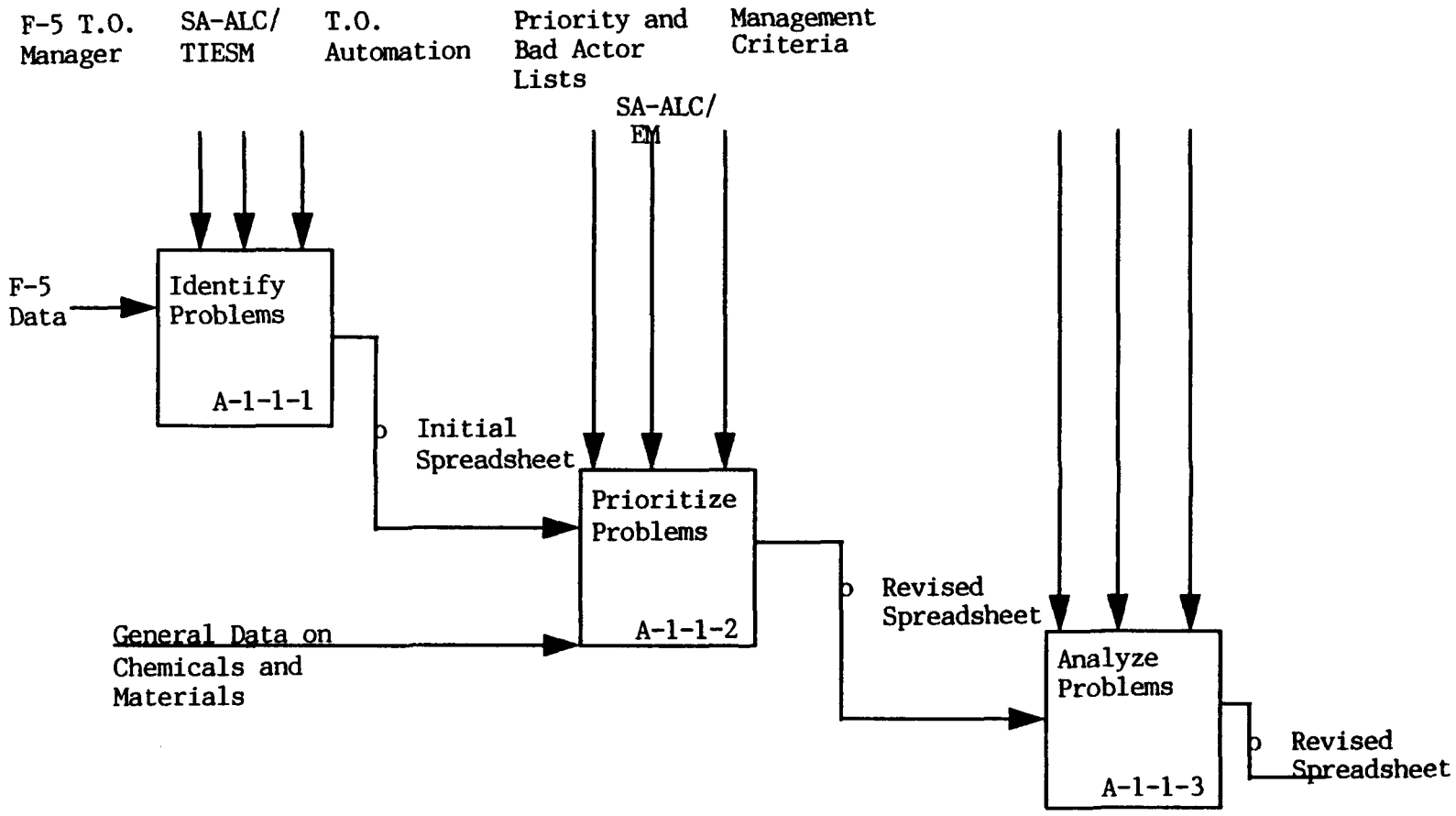

Figure 4. Develop the F-5 Pollution Prevention Program (A-1-1)

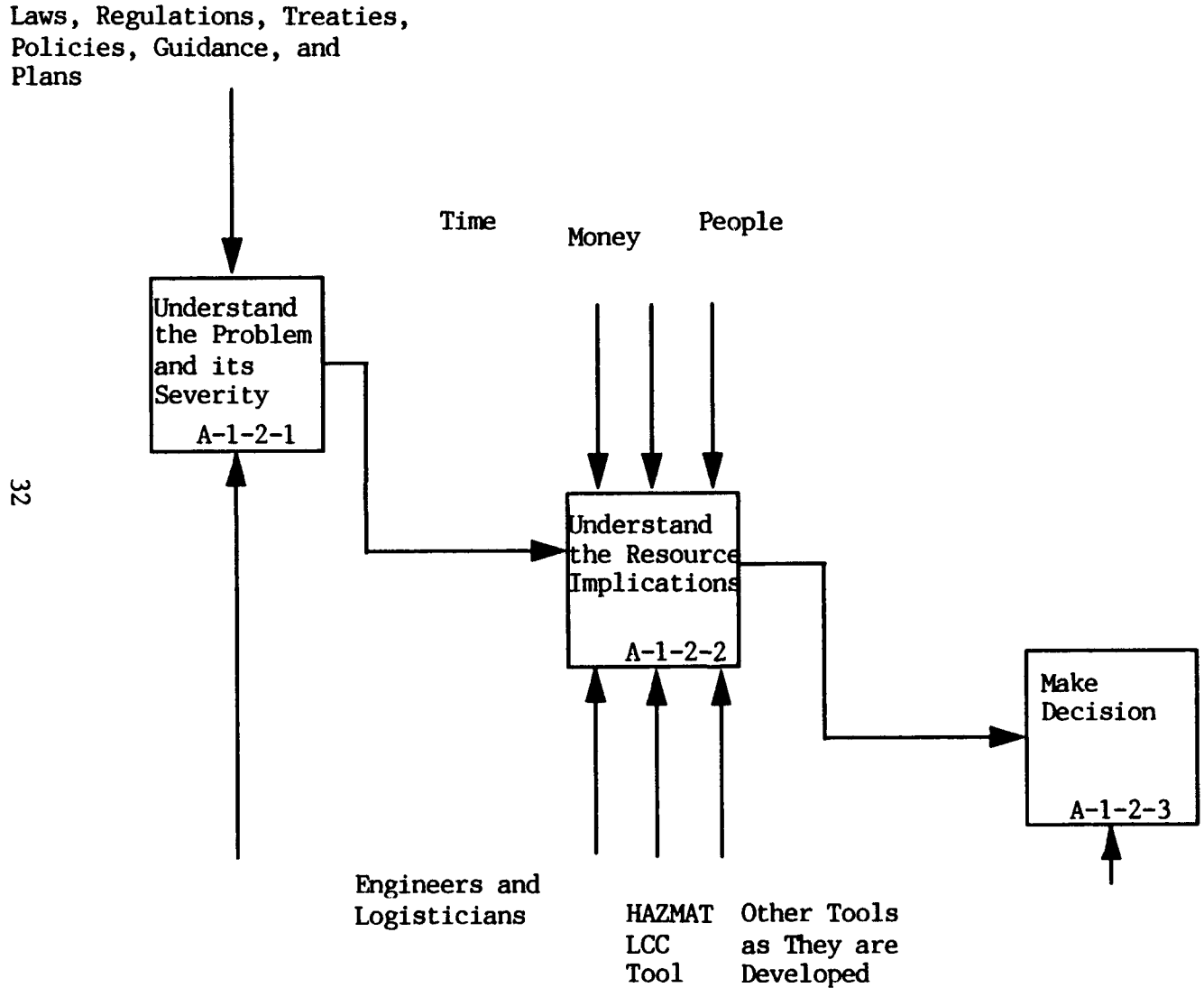

Figure 5. Make HAZMAT Decisions (A-1-2)

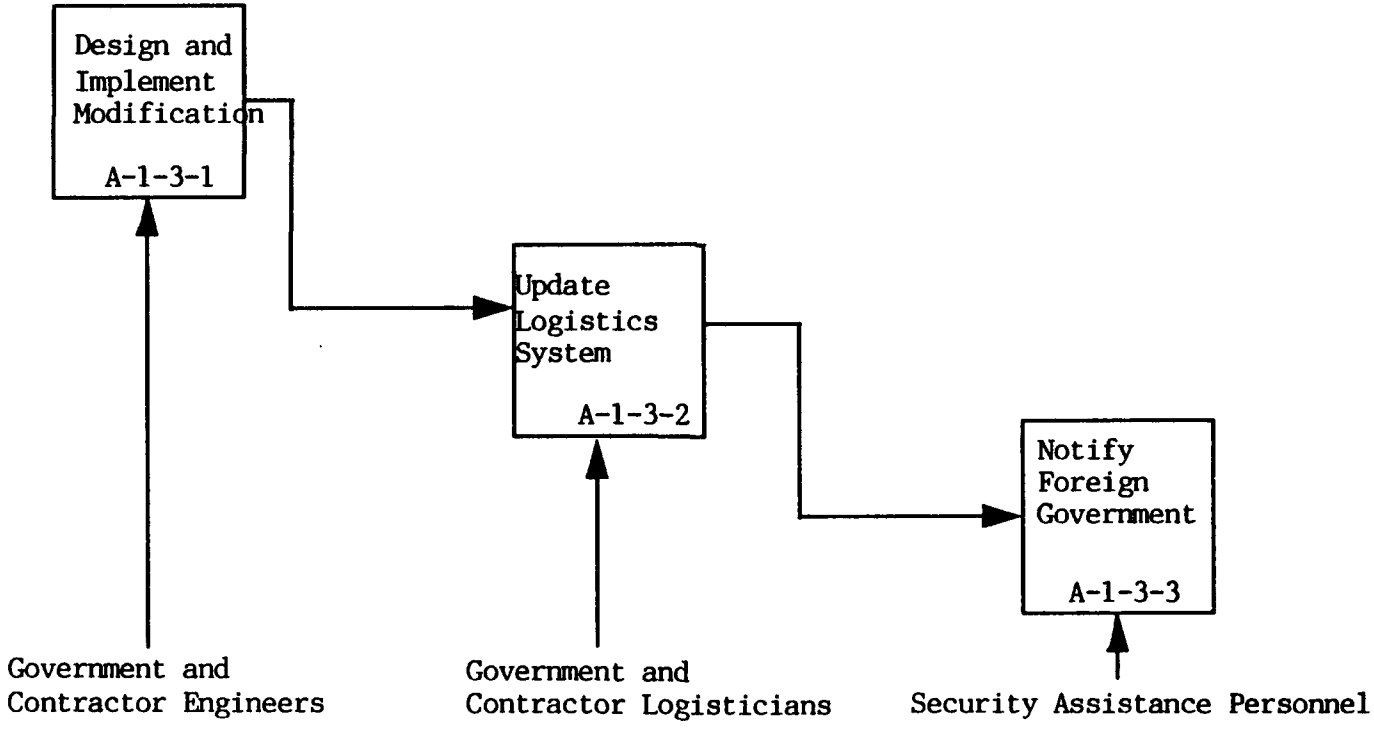

Figure 6. Implement HAZMAT Decisions (A-1-3)

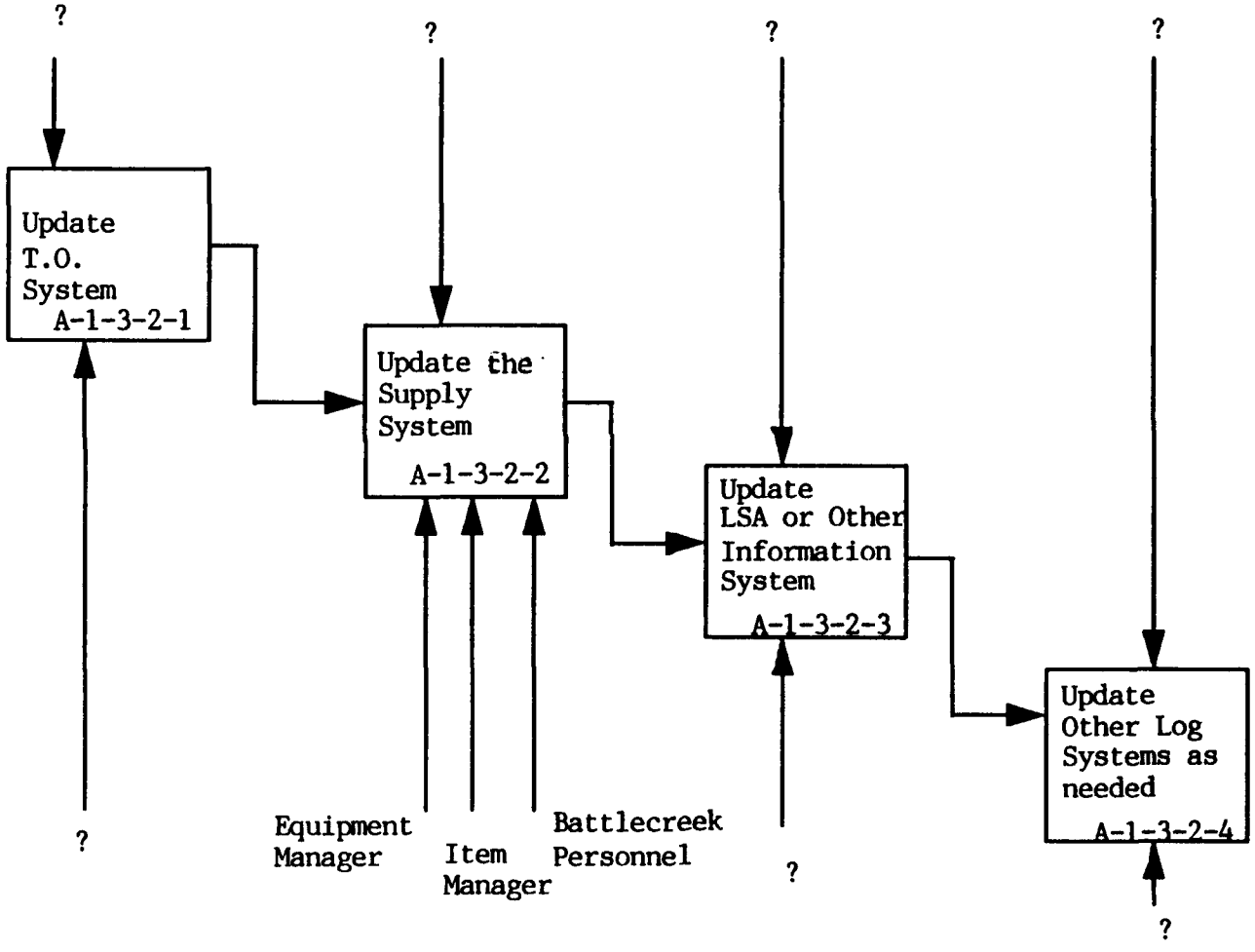

Figure 7. Update the Logistics System (A-1-3-2)

IV. Utility of This Research to Generic Pollution Prevention Programs.

General Utility.

The F-5 weapon system was deliberately chosen as a test vehicle for this Pollution Prevention effort. The F-5 itself represents the lower end of the advanced technology scale, and as such, its pollution problems may be easier to emcompass. In addition, all of the logistics supportability functions were available in one location: the Proven Aircraft Division, Kelly AFB, Texas. As the PPM Program evolves, the author will be able to expand the scope of the systems analysis to the working level. Even the six IDEFo charts that were developed have been useful in describing broad levels of activity, and identifying needs and constraints.

The F-5 program is not intended to represent the only way to accomplish pollution prevention management in the Air Force. Its utility is in demonstrating the various aspects of PPM which must occur on each program, regardless of the mechanism that is used to implement the program.

Applicability.

The F-5 Pollution Prevention Program is applicable to a variety of other efforts:

To the Navy F-5 Program. The Navy continues to fly the only F-5 aircraft still operated by the DoD. They are used as "aggressors" in Red Flag exercises. Their maintenance is done by contract. Both the Navy and the contractor program managers have been contacted, and the F-5 spreadsheets provided.

To T-38 Aircraft. There are significant similarities between the F-5 and the T-38 aircraft. Discussion has already been initiated with the T-38 Program Office at Kelly AFB.

The T-38 is also maintained using contractor support, and the contractor is expected to identify and eliminate ODCs and hazmats from the activity. T-38 office personnel obtained copies of all of the F-5 spreadsheets created to date. As additional informatiaon is developed for the F-5, copies will be forwarded to the T-38 office for their use.

To Other Aircraft Managed by the Proven Aircraft Division. Once the management structure has been set-up for the F-5 program, similar activities can be initiated for other active weapon systems.

To Other Security Assistance Program Aircraft. With the program in place in the Proven Aircraft Division, it is possible to set up briefings to discuss the development and implementation of the F-5 PPM Program, and its applicability to other Security Assistance aircraft. Initial discussions have already taken place between the Director, and personnel from the AFMC International Affairs office (AFMC/IA) and the author of this thesis. The dialog will be continued with Security Assistance personnel at Kelly AFB, as well, to determine the best approach to insuring that foreign customers have access to pollution prevention information and TO updates.

V. Recommendations

Three areas were found to need additional emphasis by the Environmental Management communities: 1. crossfeed of information, 2. a useful hazardous materials cost accounting system, and 3. better decision analysis tools.

HAZMAT Crossfeed of Information.

Individual organizations at ASC, and at the ALCs are collecting data on alternatives, research and development, and research needs. Hazmat data bases are currently available which address property, estimation, regulatory sources, hazard response, hazmat tracking, and incompatibility prediction (58:unnumbered) A major data repositiory effort, such as the one required by ASC/EMP (21:31) and proposed by HSC/EMP (7:unnumbered) is necessary to prevent extensive duplication of effort. It should also be compatable with stand alone software, as well as with such efforts as the EPA pollution Prevention Information Exchange System (97) and the Pollution Prevention Information Clearinghouse (96).

"Green" Accounting System.

DoD Directive 4210.15 Hazardous Material Pollution Prevention states that *It is DOD policy that hazardous material shall be selected, used, and managed over its life-cycle so that the Department of Defense incurs the lowest cost required to protect human health and the environment* (33). At this time it is difficult to accurately assess any of the costs of hazardous materials for a system. An accurate, complete data base of environmental costs does not exist. We need it.

One problem is that *reported 'costs' rarely distinguish between operating or maintenance expenses and capital investments (46:4).* That distinction needs to be made in an accounting system for environmental costs. The same system should allow you to allocate hazardous materials and residual costs to specific products and activities rather

than effectively hiding them in overhead accounts. Such a system should make it obvious that pollution prevention and waste minimization save money. Other issues that need to be considered are the relative costs per system by acquisition phase (4:6-7) and optimizing product profitability while minimizing costs (74:28-31).

Decision Making Criteria and Tools.

When the Program Manager is presented with the the information about alternatives, he or she must make a decision. The decision in the past has been based on a "best guess" understanding of the implications of the decision. The life cycle cost model goes a long way towards quantifying such a decision, but more work needs to be done in other types of logistics trade-off tools.

VI. Conclusions

Evaluation of Research Objective No. 1.

The first research objective of this thesis was to conduct a hazardous materials analysis of the technical documentation available for the F-5A aircraft. That activity was accomplished, and the resulting spreadsheets were provided to the F-5 program office, and a number of other organizations. The spreadsheets were then used as the basis for the development of a PPM plan as part of a PPM program.

Evaluation of Research Objective No. 2.

The second research objective of this thesis was to develop a pollution prevention program for the Air Force F-5 Program Director. Systems analysis was used to describe the F-5 PPM program, and to relate it to the broader AF PP program. The development of the program received positive support from the F-5 program office, where an IPT was initiated to continue the effort. The program is currently being used to support the F-5 system.

Evaluation of Research Objective No. 3.

The third research objective of this thesis was to develop a generic approach for developing similar pollution prevention programs for the other aircraft managed by the Proven Aircraft Division. The IDEFo systems analysis can be used as a generic description of pollution prevention management, and is readily capable of being modified for other specific programs. Documentation generated as a result of creation of the F-5 PPM program was provided to the AFMC IPT on PP. Members of the IPT are reviewing the material, and expect to use it as an example of a pollution prevention program for an existing weapon system.

Conclusion.

This thesis research successfully combined the goals of both the environmental and the security assistance programs. We in the Department of Defense have an ethical imperative to reduce to the extent possible, requirements which compel others to generate toxic and hazardous waste. In order to accomplish this objective, analysis and understanding of the processes involved is essential. Increased understanding of the problems, and interest in on-going research will encourage a variety of new and innovative approaches to pollution prevention. Substitution of one chemical, material or process for another is not the only potential solution. The following is a sampling of issues which could also be considered in a pollution prevention initiative.

1. Global monitoring. One product of the "cold war" may be put to constructive use in the management of the global environment. In collecting extensive and detailed information about military and industrial activities in countries around the world as part of the intelligence gathering effort, the government has been inadvertently collecting information about the health of the global environment. Efforts are underway to evaluate the scientific value of the intelligence data on-hand (12:66). In a related effort, a light detection and ranging system (LIDAR), developed at Los Alamos as a warning system against chemical or biological attack during Desert Shield, is being used analyze air pollution in Mexico City. The data being collected will be used to determine the effect of various cleanup options on that city's pollution problems. (54:57-58) Satellites in general have numerous uses as tools for environmental planning, and as a platform for widespread education on environmentala issues (55:9-14)

2. Funding for research. The majority of funding in the environmental budget has been used for clean-up. The amount of money spent in the past should not concern us as much as the fact that there is a disconnect between the areas that have been perceived as most important, and the amount of resources that have been committed to those areas. In her

report on federal funding for environmental research. Barbara Mandula pointed out that the Department of Defense was omitted from the estimate of funding, since most of its environmental research is connected to sight remediation (56:1498).

3. The importance of technological solutions. Alvin Alm writes the ES&T Regulatory Focus column in Environmental Science and Technology. He recently pointed out the importance of technology as a tool which can help solve a variety of environmental problems. Some of those technologies include integrated measurement and analytical systems to record and monitor environmental change; sophisticated sensors; improved computers and expert systems; new fuels; electric vehicles; and teleconferencing and communication. (1:1300). Other pollution reducing technologies include plastic grit to depaint aircraft parts or baking soda, lasers, or microorganisms to do the same job (9:24; 100:69) Hughes Aircraft Co. recently announced a technological breakthrough in the development of a new flux material which will reduce CFC based solvent use, speed manufacturing, and save millions of dollars a year (71:45). And San Antonio Air Logistics Center has developed a process that uses an orange-based, biodegradable cleaner called Citrikleen, rather than other more hazardous products, to prepare aircraft surfaces for painting (83:1). There are many more examples (73; 88:1-2)

4. Total quality management. Pollution prevention and Total Quality Management are two areas which are similar in their efforts. The opportunity to include pollution prevention into existing TQ structures could generate creative and innovative solutions to problems at the working level. (2:452) *Both TQM and pollution prevention depend on creativity, a team approach, employee empowerment and the support of corporate management* (5:35).

5. Industrial ecosystems. As a potential solution to some of the pollution prevention problem, the concept of an industrial ecosystem has merit and should appeal to the logistics community. In an industrial ecosystem, the industrial outputs of one facility

become inputs to the manufacturing process in another facility. (93:167) Obviously, a significant amount of planning is necessary to make such a system work. The benefits, however, are obvious. Industrial waste becomes a medium of exchange. The Danes have created such an industrial ecosystem. The Kalundborg complex is a closed-loop industrical ecosystem which includes an electrical power plant, an oil refinery, a biotechnology production plant, a plasterboard factory, a sulfuric acid producer, cement producers and local agricultural/horticultural developments (75:8-9).

6. The Germans have taken a different approach to pollution reduction of the municiple waste created by packaging. German legislation states that *packaging must be taken back, reused or recycled outside of the public waste management system. Following the principle that 'the polluter pays,' those who create packaging will be responsible for collecting, recycling and disposing of packaging waste (40:1).* Similar requirements could be levied on contractors supplying the DOD.

The environmental outlook is not all "doom and gloom". There is a *tremendous market potential in developing and providing expertise for the new field of environmental economics (81:26).* The cleanup and control dollars spent by a company either pay their own workers or pay their subcontractors, creating an expanding series of jobs, profits, and revenues (46:4).

To conclude that 'the enemy is us' is not especially helpful. The solution also is us. The true enemies are ignorance, inadequate response to growing dangers and resistance to change. (47:16) The attitude and the actions of the DOD and the Air Force are changing with regard to hazardous materials and pollution prevention. In the words of a slogan created for a "Green Manufacturing" conference: *The pollution you don't make, you don't have to clean up! (42)* Change will occur, but it will take time, money, and human resources to make it happen. In the words of Gary Vest, Deputy Assistant Secretary of the Air Force for Environment, Safety, and Occupational Health, *We can't*

afford to clean up to the extent we would like, but we do owe our allies responsible behavior (84:31). One important aspect of responsible behavior, championed in this thesis, is eliminating the requirement to pollute. We owe it to ourselves, our allies, and our planet.

Appendix A: F-5 Pollution Prevention Plan

Pollution Prevention Management Plan
F-5 Pollution Prevention Management Program
Developed by: Capt Janice M. Gavern
Current as of: 30 June 1993

Section I. Executive Summary.

1. **Introduction.** The F-5 Pollution Prevention Management Program provides the means by which the F-5 Program Manager is able to identify, classify, and manage the hazardous materials which have been documented as required to operate and maintain the F-5 aircraft. The goal of this program is to significantly reduce the number of such required materials and chemicals by identifying, and specifying for use, those non-hazardous alternatives which will reduce the individual and environmental risk incurred in the operation and maintenance of F-5 aircraft. Current information regarding identification, analysis, classification, and required management actions are contained in this management plan.

2. Scope. The F-5 Pollution Prevention Management Plan (PPMP) consists of two parts: an Executive Summary, and a detailed Plan, which are revised and updated quarterly. The PPMP is the vehicle which the F-5 Pollution Prevention Program Manager uses to document the current status of the Program. The F-5 Program Manager will use the plan to identify hazardous materials alternatives projects to be initiated, and to document the results of previous projects.

3. New Projects. This plan identifies 43 operational management occurrences, and 9 tactical management occurrences of hazardous chemicals or materials. This information should be used by the recently created F-5 Integrated Product Team on Pollution Prevention, headed by John Rich (DSN 945-6825), to initiate modifications which eliminate the chemical or material from use.

4. On-going Projects. There are no current on-going projects.

5. Completed Projects. There are no current completed projects.

6. Next Report. The next quarterly F-5 Pollution Prevention Management Plan will be released on 30 September 1993.

7. F-5 Pollution Prevention Plan Manager. The point-of-contact for the F-5 Pollution Prevention Management Plan is Capt Janice M. Gavern, SA-ALC/LAV, Kelly AFB, Texas. She can be reached during the week at DSN 785-9750, commercial (513) 255-9750, FAX 986-4511 or (513) 476-4511.

Section II. F-5 Pollution Prevention Plan

1. Introduction. The F-5 Pollution Prevention Management Program provides the means by which the F-5 Program Manager is able to identify, classify, and manage the hazardous materials which have been documented as required to operate and maintain the F-5 aircraft. The goal of this program is to significantly reduce the number of such required materials and chemicals by identifying, and specifying for use, those non-hazardous alternatives which will reduce the individual and environmental risk incurred in the operation and maintenance of F-5 aircraft. Current information regarding identification, analysis, classification, and required management actions are contained in this management plan.

2. Background.

a. *F-5 Program.* The primary focus of the Proven Aircraft Division (SA-ALC/ LAV) is the F-5 weapon system. The F-5 Technical Coordination Group (TCG) and Systems Program Management Branch are the focal points for international logistics support and management of the F-5 aircraft worldwide. The TCG also serves as a point of contact and central source of information on F-5 logistics issues and concerns. The F-5 Technical Coordination Group, Technical Section, represents the 23 member countries who fly the F-5, and provides them with the management expertise and information necessary to maintain technical integration, monitor design configuration, and coordinate reliability and maintainability issues. In the fall each year, the Proven Aircraft Division sponsors a world-wide review. The review will be an appropriate forum to disseminate the pollution prevention and hazardous waste minimization information developed in the F-5 Pollution Prevention Management Program..

b. *Environmental Law.* One section of the Clean Water Act is particularly relevant to the management of the F-5 program. In 33 USC 1251, the Clean Water Act (Federal Water Pollution Control Act as amended, Declaration of Goals and Policy, Sec. 101. (a), it states that "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act . . . (a.3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited; . . . (c) It is further the policy of Congress that *the President, acting through the Secretary of State and such national and international organizations* as he determines appropriate, shall take such action as may be necessary to insure that to the fullest extent possible *all foreign countries shall take meaningful action for the prevention, reduction and elimination of pollution in their waters and in international waters and for the*

achievement of goals regarding the elimination of discharge of pollutants and the improvement of water quality to at least the same extent as the United States does under its laws." (Italics added.)

3. **Authority.** On 7 January, 1993, General Merrill A. McPeak, USAF Chief of Staff, and Donald B. Rice, Secretary of the Air Force released an action memorandum which discussed the Air Force Pollution Prevention Program. It said, in part, that

"The Air Force is committed to environmental leadership. Our goal is to prevent future pollution by reducing use of hazardous materials and releases of pollutants into the environment to as near zero as feasible. To achieve this, we must quickly move away from dependence on hazardous materials, actively reduce our waste streams, reuse the wastes we do generate, recycle what we cannot reuse, and expand purchasing programs for recycled products."

In addition to the strategic goal of reducing hazardous material use, the memorandum listed six specific objectives. The F-5 Pollution Prevention Management Program, and Plan are intended to implement Objective 2: *Reduce the use of hazardous materials in existing (deployed) weapons systems by finding less hazardous materials and processes and integrating them into TOs, MILSPECS and MILSTDS.* OPR: AF/LG; OCRs: SAF/MI, AF/CE, AF/SG, AF/XO, AFMC.

4. **Methodology.** The F-5 Pollution Prevention Management Plan was developed in the following stages.

a. Analysis of the technical order data base. An initial "quick look" review of F-5 technical orders was conducted by Capt Gavern in early May. Of 181 technical orders which were scanned, 118 were identified as definitely not requiring additional analysis, and 63 technical orders were flagged as requiring some level of additional, in-depth, analysis. Capt Gavern has conducted a line-by-line analysis of five of those technical orders. Potential hazardous materials identified in the F-5A, and F-5B Powerplant technical orders will be the subject of this first management plan.

b. Creation of a F-5 specific hazardous materials management data base. Each occurrence of a potential hazardous material was entered into a spreadsheet data base to facilitate further analysis. Printouts of the two powerplant spreadsheets are attached to this document (Appendix A).

c. Compilation into a management plan. Occurrences of potential hazardous materials have been initially screened into management categories using this criteria.

a. Special Management. This category includes compound hazards, for example, materials or chemicals which are both nuclear hazards and hazardous materials; or explosive hazards and hazardous materials.

b. Operational Management. This category includes materials and chemicals which have been identified as a significant individual or environmental risk, or which require special emphasis. They require a rapid response. Suitable substitutes, or a plan for acquiring a suitable substitute should be developed within six months of identification.

c. Tactical Management. This category includes materials and chemicals which have been identified as a moderate individual or environmental risk. They require identification of suitable substitutes or a plan for acquiring such substitutes within one year of identification.

d. Strategic Management. This category includes materials and chemicals which have been identified as low individual or environmental risks. They require identification of suitable substitutes or a plan for acquiring such substitutes within two years of identification.

e. Minimum Management. This category includes materials and chemicals which are identified in F-5 aircraft technical orders but which are not considered hazardous materials at this time. These materials have been identified, and will continue to be tracked for a number of reasons. First, there are numerous examples of materials and chemicals which had been identified as harmless, but which were later identified as causing problems. Tracking all of the materials on the F-5 makes it easier to screen for such materials as they become issues. Second, within the pollution prevention community itself, criteria used to identify hazardous materials have been changing. In the past, emphasis has centered on carcinogenic risk. As broader criteria are used to determine what constitutes a hazard, more refined management categories may be required. Once again, having all of the materials tracked makes such screening more efficient and effective. Finally, managing all of the materials on a program allows us to take advantage of new technology, or product improvements. For example, there are numerous instances where petroleum jelly is used to lubricate gaskets on various components of the F-5. Suppose we are able to identify a new lubrication product which costs significantly less, or performs better, or lasts longer, or does not use petroleum

products; or a gasket material is developed which is self-lubricating. If we have identified all occurrences of the use of petroleum jelly, making the substitution, and changing the technical orders can be accomplished much more rapidly.

d. Technical risk analysis. This first management plan is intended to highlight specific occurrences that will need to be analyzed. In the future, updated plans will include the results of technical risk analysis.

e. Identification of related research. A number of organizations will be contacted to identify hazardous materials replacement research efforts currently underway which may relate to or be useful for the F-5 program.

f. Automation issues. Data identified in this first review was obtained through a "by-hand" analysis of the two technical orders. For the 65 technical orders identified to date as requiring additional evaluation, two automation categories were created. The first consists of technical orders which would be difficult to review by hand, either because of the numbers of potential occurrences, or because of the size of the technical order. The second consists of those technical orders which require additional analysis, but which need not be automated, given that a "by hand" analysis is accomplished. (Appendix B)

5. Results. Five major categories for "hazardous materials" management have been identified, ranging from the most serious to the least serious management problems.

a. *Special Management.* This category includes compound hazards, for example, materials or chemicals which are both nuclear hazards and hazardous materials; or explosive hazards and hazardous materials. At this time, no compound hazards have been identified for this program.

b. *Operational Management.* This category includes materials and chemicals which have been identified as a significant individual or environmental risk, or which require special emphasis. This category presently includes ozone layer depleting substances (OLDS) and the EPA 17 (Appendix C). At this time, the following hazardous materials have been identified for Operational Management:

	Chemical	*Identified as*	*Military designation*	*Technical Order*	*Page number*	*Line number*
1.		vapor degrease		1F-5A-2-6	3-148	9
2.				1F-5B-2-6	3-179	6

3.		solvent	P-D-680 type II	1F-5A-2-6	5-8	25
4.				1F-5B-2-6	5-6	29
5.		solvent	P-D-680 type II	1F-5A-2-6	5-18	12
6.				1F-5B-2-6	5-17	18
7.		degreasing solvent	O-T-634	1F-5A-2-6	5-19	24
8.				1F-5B-2-6	5-19	26
9.		carbon remover compound	MIL-C-25107	1F-5A-2-6	5-19	27
10.				1F-5B-2-6	5-19	28
11.		carbon remover compound	MIL-C-25107	1F-5A-2-6	7-13	30
12.				1F-5B-2-6	7-13	25
13.		cleaning fluid	P-C-111	1F-5A-2-6	5-19	31
14.				1F-5B-2-6	5-19	33
15.		cleaning fluid	P-C-111	1F-5A-2-6	7-13	35
16.				1F-5B-2-6	7-13	28
17.		solvent	P-D-680 Type II	1F-5A-2-6	6-12	13
18.				1F-5B-2-6	6-11	18
19.	trichloro-ethylene	tric	O-T-634	1F-5A-2-6	7-10	12
20.	trichloro-ethane		O-T-620	1F-5B-2-6	7-8A	3
21.		degreasing solvent	O-T-634	1F-5A-2-6	7-13	27
22.			O-T-620	1F-5B-2-6	7-13	20
23.		solvent	P-D-680 Type II	1F-5A-2-6	8-4A	30
24.				1F-5B-2-6	8-4	24
25.		solvent	P-D-680 Type II	1F-5A-2-6	13-12A	40
26.				1F-5B-2-6	11-21	?

27.		solvent	P-D-680 Type II	1F-5A-2-6	13-14	25
28.				1F-5B-2-6	13-13	11
29.		solvent	P-D-680 Type II	1F-5A-2-6	13-20	19
30.				1F-5B-2-6	13-19	37
31.		solvent	P-D-680 Type II	1F-5A-2-6	13-21	42
32.				1F-5B-2-6	13-21	25
33.		solvent	P-D-680 Type II	1F-5A-2-6	13-23	25
34.				1F-5B-2-6	13-22A	12
35.		solvent	P-D-680 Type II	1F-5A-2-6	13-25	36
36.				1F-5B-2-6	13-26	10
37.		solvent	P-D-680 Type II	1F-5A-2-6	13-28	17
38.				1F-5B-2-6	13-27	24
39.		zinc chromate putty	MIL-P-8116	1F-5A-2-6	14-4	33
40.				1F-5B-2-6	14-4	29
41.		zinc chromate putty	MIL-P-8116	1F-5A-2-6	14-6	30
42.				1F-5B-2-6	14-7	10
43.				1F-5B-2-6	14-9	18

c. *Tactical Management.* This category includes materials and chemicals which have been identified as a moderate individual or environmental risk. At this time, the following hazardous materials have been identified for Tactical Management:

	Chemical	*Identified as*	*Military designation*	*Technical Order*	*Page number*	*Line number*
1.		preservative		1F-5A-2-6	3-100	9
2.				1F-5B-2-6	3-103	9
3.		calibration fluid	MIL-F-7024	1F-5A-2-6	3-100L	13
4.				1F-5B-2-6	3-114	13

5.		insulation blanket		1F-5A-2-6	4-4	21
6.				1F-5B-2-6	4-5	21
7.		insulation blankets and shrouds		1F-5A-2-6	12-12	17
8.				1F-5B-2-6	12-12	16
9.				1F-5B-2-6	12-12	34

d. *Strategic Management.* This category includes materials and chemicals which have been identified as low individual or environmental risks. At this time, there are no materials or chemicals identified for Strategic Management.

e. *Minimum Management.* This category includes materials and chemicals which are identified in F-5 aircraft technical orders but which are not considered hazardous materials at this time. The following chemicals and materials were identified:

1. hydraulic fluid
2. petrolatum
3. lubricating oil
4. spray lube
5. graphite grease
6. antiseize compound
7. solid film lubricant
8. high temperature sealant
9. WD-40
10. Rust Lick
11. grease
12. sealing compound
13. milk of magnesia

6. Metrics.

a. Summary Statistics. Technical Order 1F-5A-2-6 has 704 pages, and 1F-5B-2-6 has 709 pages. Those 1,413 pages were reviewed by hand. 120 materials and chemicals were listed in 1F-5A-2-6, and 123 chemicals and materials were listed in 1F-5B-2-6 as used on the F-5 aircraft.

b. Category Statistics.

1. Special Management. No chemicals or materials were identified for special management.

2. Operational Management. 43 chemicals and materials were identified for operational management. Life cycle cost and other resource requirements have not been identified to date.

3. Tactical Management. Nine chemicals and materials were identified for tactical management.

4. Strategic Management. No chemicals and materials were identified for strategic management.

5. Minimum Management. 13 types of chemicals and materials were identified for minimum management.

c. Existing Non Hazardous Alternatives. During the next quarter, the chemicals and materials identified for operational management will be screened to determine is a non hazardous alternative is available for each chemical or material for each separate process. Results of the screening will be documented in the next quarterly report.

d. Existing Acquisition Development Efforts. In the event that a non-hazardous alternative is not available, existing efforts to develop an environmentally sound alternative will be identified. For example, there is an Air Force wide halon replacement program.

e. New Acquisition Development Efforts. If no such development effort exists, the F-5 Program Office will initiate a project to develop an alternative.

7. F-5 Pollution Prevention Plan Manager. The point-of-contact for the F-5 Pollution Prevention Management Plan is Capt Janice M. Gavern, SA-ALC/LAV, Kelly AFB, Texas. She can be reached during the week at DSN 785-9750, commercial (513) 255-9750, FAX 986-4511 or (513) 476-4511.

8. Summary. This is the first issue of the quarterly F-5 Pollution Prevention Management Plan. It details the initial identification of potential hazardous materials which will eventually be eliminated from use on the F-5 weapon system. Subsequent quarterly plans will describe additional analysis, and identification and replacement of the hazardous materials with environmentally sound alternatives.

Definitions

Alternatives. Ways of reducing adverse effects of HAZMATs. Alternatives, as applied to HAZMAT decision-making include, but are not limited to, such possibilities as substituting less hazardous or nonhazardous material; redesigning a component such that the HAZMAT is not needed in its manufacture, use, or maintenance; modifying processes or procedures; restricting users; consumptive use; on-demand supply; direct ordering; extending shelf life; regenerating spent material; downgrading and reuse of spent material; use of waste as raw material in other manufacturing and combinations of those factors. Alternatives are to be analyzed in a "could cost" approach, considering what the lowest amount the decision could cost by overcoming barriers to getting the job done, while ensuring protection of human health and the environment.

Hazardous Materials. A system-related material is considered hazardous in the context of a Hazardous Materials Management Program if available information states or suggests that the material itself, or any of its ingredients, poses a significant potential hazard in any of these seven categories: acute health, chronic health, cancer, contact, flammability, reactivity or environmental, or data is insufficient to determine that a significant potential hazard does not exist in any of these categories, and the material is used in sufficient quantity to allow that potential hazard to be realized.

Hazardous Materials Management Program Plan. A description of the planned tasks and activities to be used by the Program Manager to implement the system Hazardous Materials Management Program. It is the Hazardous Materials Management Program Manager's approach to assure appropriate consideration is given to the reduction/elimination of hazardous materials from system(s), system components, and associated support items. The emphasis is on eliminating or reducing hazardous materials in system processes and products.

Hazardous Materials Life Cycle Costs. Those costs that are incurred by the government due to the use of hazardous materials. Typical costs include procurement, disposal, personnel protection, medical surveillance, facilities, transportation and toxic torts.

Hazardous Wastes. By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed; possesses at least one of five characteristics (toxic, corrosive, ignitable, explosive, or chemically reactive) or are listed in 40 CFR 261-3 or applicable state or local waste management regulations.

Ozone Depleting Chemicals (ODCs). Chemicals that, when released into the atmosphere, result in the destruction of the earth's stratospheric ozone layer. They include Chlorofluorocarbons (CFCs), halons, and other substances as classified by the Clean Air Act of 1990. The term is synonymous with ODS (Ozone Depleting Substance) and OLDS (Ozone Layer Depleting Substance).

Pollution Prevention. All the actions necessary, to include use of processes, practices, products or management actions, that eliminate or reduce undesirable impacts on human health and the environment. These actions form a hierarchy of source reduction, recycling, treatment, and disposal.

References

Air Force Regulation (AFR) 19-1, *Pollution Abatement and Environmental Quality*, January, 1978.

AFR 19-7, *Environmental Pollution Monitoring*, April, 1985.

AFR 19-8, *Environmental Protection Committees and Environmental Reporting*, August, 1988.

AFR 19-9, *Interagency/Intergovernmental Coordination of Land, Facility Environmental Plans, Programs and Projects*, February, 1986.

AFR 19-15, *Reduction in Use of Chlorofluorocarbons, Halons, and Other Substances that Deplete Stratospheric Ozone*, 30 Sep 91.

Department of Defense Directive (DODD) 4210.15, *Hazardous Material Pollution Prevention*, 27 Jul 89.

DODD 5000.1, *Major and Non-Major Defense Acquisition Programs*, Feb 91.

DODD 6050.1, *Environmental Effects in the United States of DOD Actions*, XXXX.

Department of Defense Instruction (DODI) 5000.2, *Defense Acquisition Management Policies and Procedures*, Feb 91.

DODI 5000.2M, *Defense Acquisition Management Documentation and Report*, Feb 91.

Department of Defense Manual (DODM) 6050.5M, *DOD Hazardous Materials Information System Procedures.*, XXXX.

Military Standard (MIL-STD) 337, *Design to Cost*, XXXX.

MIL-STD-499A, *Systems Engineering*, XXXX.

MIL-STD-882, *Systems Safety Program Requirements*, XXXX.

MIL-STD-1388-1A, *Logistics Support Analysis*, XXXX.

MIL-STD-13882B, *DOD Requirements for a Logistic Support Analysis Record*, XXXX

MIL-STD-1521B, *Technical Reviews and Audits for Systems, Equipment and Computer Programs*, XXXX.

Secretary of the Air Force Memorandum, *Air Force Pollution Prevention Program*, 7 January 1993.

Appendix A

The F-5A and F-5B Pollution Prevention Management spreadsheets.

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: December 1992**

Basic: 1 May 1971 through Change 15: 1 March 1986

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	hydraulic fluid		MIL-H-83282 or MILL-H-5606			1-46	31
Comment: Maintenance personnel use a hydraulic test stand to provide external hydraulic power tto operate the various aircraft sy							
Comment: Personnel may be exposed to spillage.							
	petrolatum		VV-P-236			2-4	24
Comment: Apply to preformed packings.							
	lubricating oil		MIL-L-7808	T.O. 42B2-1-1		2-4	27
Comment: Lubricate packing grooves, lead-in chamfers, bores, and outside diameters over which preformed packings must pass.							
Comment: Page 2-4A and 2-5 contain a chart listing engine lubricants.							
	preservative			T.O. 2J-J85-66-1		3-100	9
Comment: Ensure that the engine has been preserved before removal of quick engine change components.							
	calibration fluid		MIL-F-7024			3-100L	13
Comment: If fuel flowmeter is to be stored, ensure that flowmeter is filled with calibration fluid to protect internal parts.							
	spray lube	Lubri-Bond			FSN 9150-754-0064	3-103	3
Comment: Lubriciate trunnion mount balls with Lubri-Bond spray lube.							
	graphite grease		MIL-G-21164			3-110	11
[illegible] of graphite grease							
	spray lube	Lubri-Bond A	MIL-L-23398			3-111	15
Comment: Lubricate preformed packing groove and inner surface of right half (of slip-joint coupler) with Lubril-Cond A.							
	lubricating oil		MIL-L-7808			3-116	8
Comment: Coat all afterburner attach bolts with lubricating oil.							
	antiseize com	Jet-lube SS-30 (Hi-Temp)			FSN 8030-180-6315	3-119 & 3-121	16 22
Comment: Before installing manifold, coat attach bolt threads with Jet-Lube SS-30 (Hi-Temp).							
	petrolatum		VV-P-236			3-127	26
Comment: Lubricate preformed packing (on fuel flowmeter transmitter) with petrolatum.							
	petrolatum		VV-P-236			3-129	20
Comment: Lubricate seals (on fuel inlet manifold mounting studs) with petrolatum.							
	oil		MIL-L-25681			3-132	4
Comment: Lubricate remote speed control cables with oil.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
stems.		maintenance				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	vapor degrease			T.O. 2J-1-13		3-148	9
Comment:	Vapor degrease parts in accordance with Process 1, T.O. 2J-1-13.						
	acetone		O-A-51			3-148	27
Comment:	Rinse parts in clean reagent grade acetone, and air dry.						
	solid film lubricant				FSN 9150–964-9228	3-148	32
Comment:	Use Solid Film Lubricant to lubricate parts.				FSN 9150-964-9244		
				T.O. 1F-5A-3		3-152	5
Comment:	The engine bay firewalls must be cleaned at prescribed intervals to prevent buildup of residue.						
	high-temperature sealant			T.O. 1F-5A-3		3-152	7
Comment:	If any firewall access panels are removed the panels must be resealed with high-temperature sealant.						
		Rust-Lick No. 606		T.O. 2J-J185-102		3-153	6
Comment:	Clean the engine compressor section using reverse Rust-Lick and water-wash.						
	corrosion prev	WD-40		T.O. 2J-J85-102		3-153	19
Comment:	Use only WD-40 or Rust-Lick No. 606 to preserve engine. Do not mix WD-40 and Rust-Lick.						
	insulation blanket					4-4	21
Comment:	This is the compressor casing insulation blanket.						
	antiseize com	Ease-Off 990			FSN 8030-664-6146	4-44	6
	graphite silicone grease		MIL-A-907		FSN 9150-735-1800	4-44	7
Comment:	Lubricate threads on flexible drive shaft coupling nuts with antiseize compound or graphite silicone grease.						
	oil		MIL-L-7808			5-8	8
Comment:	All line fittings on fuel control should be lubricated with oil.						
	solvent		P-D-680 Type II			5-8	25
Comment:	Clean gearbox axis D shaftgear internal splines with P-D-680 Type II pressurized at 25 psig with shop air.						
	grease	Plasti-lube Moly No.3			FSN 9150-823-0845	5-8	35
Comment:	Lubricate pump splined shaft and gearbox axis D internal spline sparingly with grease.						
	antiseize compound		MIL-T-5544			5-8	37
Comment:	Lubricate threads of the four studs on engine gearbox mounting pad with antiseize compound.						
	antiseize compound		MIL-T-5544			5-10	14
Comment:	Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.						
	petrolatum		VV-P-236			5-10	16
Comment:	Lubricate fuel inlet manifold seals with petrolatum.						
	petrolatum		VV-P-236			5-10	36
Comment:	Lightly lubricate the three preformed packings (on the main fuel pump) with petrolatum.						

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		cleaning				
		cleaning				
		lubrication				
		cleaning				
		resealing				
		cleaning				
		preserving		4 ozs		
		maintenance				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			5-10	39
Comment: Lubricate studs (for the main fuel pump) with antiseize compound.							
	petrolatum					5-10A	14
Comment: Lubricate packing (for the high pressure relief valve cover) with petrolatum before installation.							
	antiseize com	Ease-Off 990			FSN 8030-664-6146	5-11	15
	graphite silicone grease		MIL-A-907			5-11	16
Comment: Lubricate threads on the four bolts (on the main fuel nozzel) with antiseize compound or graphite silicone grease.							
	petrolatum		VV-P-236			5-13	35
Comment: Lubricate preformed packing (main fuel control filter) with petrolatum.							
	oil		MIL-L-7808			5-13	37
Comment: Apply oil to threads of access plug (main fuel control filter).							
	petrolatum		VV-P-236			5-15	10
Comment: Lubricate new preformed packing (main fuell pump filter) with petrolatum.							
	oil		MIL-L-7808			5-15	12
Comment: Apply oil to threads of cap and spring assemble on the main fuel pump filter.							
	solvent		P-D-680 Type II			5-18	12
Comment: Using solvent P-D-680 pressurized at 25 psi with shop air, blast-flush internal splines on the overspeed governor.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	5-18	28
Comment: Lubricate mating splines on governor and gearbox with grease.							
	degreasing solvent		O-T-634			5-19	24
Comment: This procedure uses an ultrasonic cleaning unit. If one is not available, clean filter elements in accordance with T.O. 2J-1							
Comment: Clean filter parts except preformed packings and filter element by washing in degreasing solvent.							
Comment: This procedure also applies to the oil filter parts.							
	carbon remover compound		MIL-C-25107			5-19	27
Comment: Soak filter element for 30 minutes in carbon remover compound before placing element in ultrasonic cleaning unit.							
Comment: This procedure also applies to the oil filter element.						7-13	30
	cleaning fluid		P-C-111			5-19	31
			P-C-436			5-19	31
Comment: Place filter element into steel basket in ultrasonic cleaning tank for one hour.							
Comment: This procedure applies to the main fuel control filter and to the main fuel pump filter.							
Comment:It also applies to the afterburner high-pressure filter and the afterburner fuel control filter.							
Comment: It also applies to the oil filter element.						7-13	35
	solvent		P-D-680 Type II			6-12	13
Comment: Use P-D-680, pressurized at 25 psig, to blast-flush internall splines on the afterburner fuel control and pump assembly.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubricate				
		cleaning				
13.						
		cleaning				
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		cleaning				
		cleaning				
		cleaning				
		cleaning				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	oil		MIL-L-7808			6-12	32
Comment: All line fittings on the fuel control should be lubricated with oil.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	6-12	35
Comment: Lubricate afterburner fuel pump splined shaft and gearbox axis E shaftgear internal apline with grease.							
	petrolatum		VV-P-236			6-12	36
Comment: Lubricate preformed packing seal on afterburner fuel control and pump assembly with petrolatum.							
	antiseize compound		MIL-T-5544			6-13	39
Comment: Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.							
	petrolatum		VV-P-236			6-13	41
Comment: Lubricate fuel inlet manifold seals with petrolatum.							
	petrolatum		VV-P-236			6-14	20
Comment: Lubricate preformed packings on afterburner fuel pump with petrolatum.							
	antiseize compound		MIL-F-5544			6-14	22
Comment: Lubricate studs for the afterburner fuel pump with antiseize compound.							
	petrolatum		VV-P-236			6-16	14
Comment: Lubricate preformed packings for the afterburner high-pressure filter with petrolatum.							
	oil		MIL-L-7808			6-16	17
Comment: Apply oil to threads of afterburner high-pressure filter head.							
	petrolatum		VV-P-236			6-16	32
Comment: Lubricate new preformed packing for the afterburner fuel control filter with petrolatum.							
	oil		MIL-L-7808			6-16	34
Comment: Apply oil to threads of access plug for the afterburner fuel control filter.							
	oil		MIL-L-7808			6-20	7
Comment: Lubricate threads of all coupling nuts for the afterburner main fuel manifold with oil.							
	oil		MIL-L-7808			6-20	26
Comment: Lubricate threads of all coupling nuts for the afterburner pilot fuel manifold with oil.							
	oil		MIL-L-7808			6-20A	22
Comment: Lubricate threads on afterburner main spraybar with oil.							
	oil		MIL-L-7808			6-20A	37
Comment: Lubricate threads on afterburner pilot spraybar with oil.							
	antiseize compound		MIL-T-5544			7-6	20
Comment: Lubricate mounting studs on engine gearbox and all bolts and screws to be installed with the oil reservoir and oil pump w							
	petrolatum		VV-P-236			7-6	22
Comment: Lubricate each preformed packing to be installed with the oil reservoir and oil pump with petrolatum.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
ith antiseize.		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			7-6	33
Comment: Lubricate mounting studs on oil pump with antiseize compound.							
	oil		MIL-L-7808			7-6	37
Comment: Lubricate spline of oil pump and mating spline in engine gearbox with oil.							
	antiseize compound		MIL-T-5544			7-7	12
Comment: Apply antiseize compound to line connections on top of oil reservoir.							
	oil		MIL-L-7808			7-8	8
Comment: Before attaching oil cooler lines, lubricate connecting fittings with oil.							
	petrolatum		VV-P-236			7-8	12
Comment: Lubricate new preformed packings for the oil cooler installation with petrolatum.							
trichloroethylene	tric		O-T-634			7-10	12
Comment: Clean all parts of the oil filter assembly with trichloroethylene.							
	petrolatum		VV-P-236			7-10	30
Comment:Lubricate new preformed packing for the oil filter with petrolatum.							
	petrolatum		VV-P-236			7-11	10
Comment: Lubricate preformed packing for the oil pressure transmitter with petrolatum.							
	oil		MIL-L-7808			7-13	4
Comment: Fill engine oil system with oil to the FULL mark on dipstick.							
	degreasing solvent		O-T-634			7-13	27
Comment: Clean oil filter parts, except preformed pacckings and filter element, by washing in degreasing solvent.							
	solvent		P-D-680 Type II			8-4A	30
Comment: Use P-D-680 pressurized at 25 psig with shop air to blast-flush internal splines on the variable exhaust nozzle power unit.							
	oil		MIL-L-7808			8-6	5
Comment: Coat threads of studs for the variable exhaust nozzle power unit.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	8-6	6
Comment: Lubricate the mating splines of the exhaust nozzle power unit and engine gearbox sparingly with grease.							
	antiseize compound				FSN 8030-664-6146	8-6	38
	graphite silicone grease		MIL-A-907			8-6	38
Comment: Coat threads of variable exhaust nozzle actuator attach bolts with antiseize compound or graphite silicone grease.							
	oil		MIL-L-7808			8-13	8
Comment: Service the variable exhaust nozzle power unit with oil until oil level is even with lower surface of oil check port.							
	sealing compound		MIL-S-45180			9-5	12
Comment: Apply a small amount of sealing compound onto compressor casing bleed valve mounting flange.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		servicing				
		cleaning				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		servicing				
		sealing				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			9-5	14
Comment: Lubricate threads of all screws on the bleed valve assembly with antiseize compound.							
magnesium oxide	milk of magnesia				FSN 6505-684-8868	10-12	8
Comment: Lubricate threads of engine main igniter plug and lead coupling nut with milk of magnesia.							
Comment: This also applies to the engine afterburner igniter plug and ignition exciter.						10-20	3, 24
	antiseize com	Ease-Off 990			FSN 8030-664-6146	10-12	31
	graphite silicone grease		MIL-A-907			10-12	32
Comment: Lubricate threads of four screws and two strap nuts with antiseize compound or graphite silicone grease.							
	dry lubricant		MIL-L-23398			10-21	3
	Oil		MIL-L-7808			12-9	21
Comment: Lubricate alternator-tachometer generator mounting studs.							
	petrolatum		FedSpecVV-P-236			12-11	23
Comment: Lubricate preformed packings.							
	insulation blankets and shrouds					12-12	17
Comment: Engine afterburner section.							
Magnesium oxide	Milk of magnesia				FSN 6506-684-8868	12-12	28
Comment: Lubricate diffuser bosses and harness coupling nuts with milk of magnesia.							
	hydraulic fluid		MIL-H-5606			13-7	36
Comment: Prime hydraulic pump by filling pump case thru intake port with hydraulic fluid.							
	solvent		P-D-680 Type II			13-12A	40
Comment:Installing AC generator.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	antiseize compound		MIL-T-5544			13-13	22
Comment: Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-13	24
Comment: Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.							
	hydraulic fluid		MIL-H-5606			13-14	7
Comment: Before installing hydraulic pump on accessory gearbox, prime pump with red fluid.							
	solvent		P-D-680 Type II			13-14	25
Comment: Installing hydraulic pump.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	antiseize compound		MIL-T-5544			13-14	36
Comment: Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		insulation				
		lubrication				
		prime pump				
		cleaning				
		lubrication				
		lubrication				
		prime pump				
		cleaning				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-14	38
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	solvent		P-D-680 Type II			13-20	19
Comment:	Installing Northrop airframe-mounted gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-20	31
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-20	33
Comment:	Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.						
	solvent		P-D-680 Type II			13-21	42
Comment:	Installing Bendix airframe-mounted gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-22	10
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-21	12
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-23	25
Comment:	Installing Northrop engine gearbox power shaft coupling.						
Comment:	Blast flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-23	38
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-23	40
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-25	36
Comment:	Installing Bendix engine gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease		MIL-G-81322			13-26	9
Comment:	Lubricate engine power shaft coupling internal splines and engine gearbox axis B shaft gear (internal) splines with grease						
	antiseize compound		MIL-T-5544			13-26	13
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-28	17
Comment:	Replacing Northrop power shaft coupling quill shaft.						
Comment:	Blast-flush internal splines using solvent pressurized at 25 psig with shop air.						

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-28	27
Comment: Lubricate coupling internal spline with grease.							
	lubricating oil		MIL-L-7808			13-29	4
Comment: Fill gearbox with oil using hand oil can. Fill gearbox until oil runs out of filler tube.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-4	33
Comment: Apply a thin coat of zinc chromate putty to mating surface of cockpit throttle quadrant assembly.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-6	30
Comment: Apply a thin coat of zinc chromate putty to mating surfaces of engine bay cable quadrant.							
No lubricant listed.						14-8	26
Comment: Lubricate cable holes in pressure seals when installing throttle quadrant cables.							
	oil					15-78	17
Comment: Oil leakage measured in drops per minute.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		servicing				
		lubrication				
		lubrication				
		lubrication				
		troubleshooting				
.....						

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: 30 April 1993**
T.O. 1F-5B-2-6 ***Powerplant***
Basic: Through Change Number:

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	hydraulic fluid		MIL-H-83282 or MILL-H-5606			1-53	12
Comment: Maintenance personnel use a hydraulic test stand to provide external hydraulic power tto operate the various aircraft sy							
Comment: Personnel may be exposed to spillage.							
	petrolatum		VV-P-236			2-4	26
Comment: Apply to preformed packings.							
	lubricating oil		MIL-L-7808	T.O. 42B2-1-1		2-5	7
Comment: Lubricate packing grooves, lead-in chamfers, bores, and outside diameters over which preformed packings must pass.							
Comment: Page 2-4A and 2-5 contain a chart listing engine lubricants.							
	preservative			T.O. 2J-J85-66-1		3-103	9
Comment: Ensure that the engine has been preserved before removal of quick engine change components.							
	calibration fluid		*MIL-F-7024*			3-114	13
Comment: If fuel flowmeter is to be stored, ensure that flowmeter is filled with calibration fluid to protect internal parts.							
	spray lube	Lubri-Bond			FSN 9150-754-0064	3-102	30
Comment: Lubriciate trunnion mount balls with Lubri-Bond spray lube.							
	cleaning compound		MIL-C-18687			3-102	30
Comment:							
	graphite grease		MIL-G-21164			3-138	11
Comment: Coat internal mating surfaces of the throttle control quick-disconnect rod with a thin film of graphite grease.							
	spray lube	Lubri-Bond A	MIL-L-23398			3-139	14
Comment: Lubricate preformed packing groove and inner surface of right half (of slip-joint coupler) with Lubri-Cond A.							
		solid film lubricant	MIL-L-46147			3-139	14
Comment:							
	lubricating oil		MIL-L-7808	T.O. 42B2-1-1		3-146	8
Comment: Coat all afterburner attach bolts with lubricating oil.							
	antiseize com	Jet-lube SS-30 (Hi-Temp)			8030-00-180-6315	3-149	16
Comment: Before installing manifold, coat attach bolt threads with Jet-Lube SS-30 (Hi-Temp).						3-151	22
	petrolatum		VV-P-236			3-157	26
Comment: Lubricate preformed packing (on fuel flowmeter transmitter) with petrolatum.							

Current Practice is to use:	*Non-hazardous alternative*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		maintenance				
stems.						
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

	petrolatum		VV-P-236			3-159	20
Comment:	Lubricate seals (on fuel inlet manifold mounting studs) with petrolatum.						
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	oil		MIL-L-25681		9150-00-543-7220	3-162	4
Comment:	Lubricate remote speed control cables with oil.						
	vapor degrease			T.O. 2J-1-13		3-179	6
Comment:	Vapor degrease parts in accordance with Process 1, T.O. 2J-1-13.						
	acetone		O-A-51			3-179	24
Comment:	Rinse parts in clean reagent grade acetone, and air dry.						
	solid film lubricant				FSN 9150–964-9228	3-179	29
Comment:	Use Solid Film Lubricant to lubricate parts.				FSN 9150-964-9244		
				T.O. 1F-5A-3		3-182	4
Comment:	The engine bay firewalls must be cleaned at prescribed intervals to prevent buildup of residue.						
	high-temperature sealant			T.O. 1F-5A-3		3-182	7
Comment:	If any firewall access panels are removed the panels must be resealed with high-temperature sealant.						
		Rust-Lick No. 606		T.O. 2J-J185-102		3-182	10
Comment:	Clean the engine compressor section using reverse Rust-Lick and water-wash.						
	corrosion prev	WD-40		T.O. 2J-J85-102		3-182	23
Comment:	Use only WD-40 or Rust-Lick No. 606 to preserve engine. Do not mix WD-40 and Rust-Lick.						
	insulation blanket					4-5	21
Comment:	This is the compressor casing insulation blanket.						
	antiseize com	Ease-Off 990			FSN 8030-664-6146	4-45	6
	graphite silicone grease		MIL-A-907		FSN 9150-735-1800	4-45	7
Comment:	Lubricate threads on flexible drive shaft coupling nuts with antiseize compound or graphite silicone grease.						
	oil		MIL-L-7808			5-6	11
Comment:	All line fittings on fuel control should be lubricated with oil.						
	solvent		P-D-680 Type II			5-6	29
Comment:	Clean gearbox axis D shaftgear internal splines with P-D-680 Type II pressurized at 25 psig with shop air.						
	grease	Plasti-lube Moly No.3			FSN 9150-823-0845	5-6A	5
Comment:	Lubricate pump splined shaft and gearbox axis D internal spline sparingly with grease.						
	antiseize compound		MIL-T-5544			5-6A	7
Comment:	Lubricate threads of the four studs on engine gearbox mounting pad with antiseize compound.						
	antiseize compound		MIL-T-5544			5-8	10
Comment:	Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.						
	petrolatum		VV-P-236			5-8	12

Current Practice is to use:	*Non-hazardous alternative*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		cleaning				
		cleaning				
		lubrication				
		cleaning				
		resealing				
		cleaning				
		preserving		4 ozs		
		maintenance				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

Comment:	Lubricate fuel inlet manifold seals with petrolatum.						
	petrolatum		VV-P-236			5-8	34
Comment:	Lightly lubricate the three preformed packings (on the main fuel pump) with petrolatum.						
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	antiseize compound		MIL-T-5544			5-8	38
Comment:	Lubricate studs (for the main fuel pump) with antiseize compound.						
	petrolatum					5-8A	13
Comment:	Lubriciate packing (for the high pressure relief valve cover) with petrolatum before installation.						
	antiseize com	Ease-Off 990			FSN 8030-664-6146	5-11	31
	graphite silicone grease		MIL-A-907			5-11	323
Comment:	Lubricate threads on the four bolts (on the main fuel nozzel) with antiseize compound or graphite silicone grease.						
	petrolatum		VV-P-236			5-12	33
Comment:	Lubricate preformed packing (main fuel control filter) with petrolatum.						
	oil		MIL-L-7808			5-12	35
Comment:	Apply oil to threads of access plug (main fuel control filter).						
	petrolatum		VV-P-236			5-14	10
Comment:	Lubricate new preformed packing (main fuell pump filter) with petrolatum.						
	oil		MIL-L-7808			5-14	12
Comment:	Apply oil to threads of cap and spring assemble on the main fuel pump filter.						
	solvent		P-D-680 Type II			5-17	18
Comment:	Using solvent P-D-680 pressurized at 25 psi with shop air, blast-flush internal splines on the overspeed governor.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	5-17	29
Comment:	Lubricate mating splines on governor and gearbox with grease.						
	degreasing solvent		O-T-634			5-19	26
Comment:	This procedure uses an ultrasonic cleaning unit. If one is not available, clean filter elements in accordance with T.O. 2J-1						
Comment:	Clean filter parts except preformed packings and filter element by washing in degreasing solvent.						
Comment:	This procedure also applies to the oil filter parts.						
	carbon remover compound		MIL-C-25107			5-19	28
Comment:	Soak filter element for 30 minutes in carbon remover compound before placing element in ultrasonic cleaning unit.						
Comment:	This procedure also applies to the oil filter element.					7-13	25
	cleaning fluid		P-C-111			5-19	33
			P-C-436			5-19	33
Comment:	Place filter element into steel basket in ultrasonic cleaning tank for one hour.						
Comment:	This procedure applies to the main fuel control filter and to the main fuel pump filter.						

Current Practice is to use:	*Non-hazardous alternative*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubricate				
		cleaning				
13.						
		cleaning				
		cleaning				
		cleaning				
		cleaning				

Comment:It also applies to the afterburner high-pressure filter and the afterburner fuel control filter.							
Comment: It also applies to the oil filter element.						7-13	28
	solvent		P-D-680 Type II			6-11	18
Comment: Use P-D-680, pressurized at 25 psig, to blast-flush internall splines on the afterburner fuel control and pump assembly.							
	oil		MIL-L-7808			6-11	32
Comment: All line fittings on the fuel control should be lubricated with oil.							
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	6-11	35
Comment: Lubricate afterburner fuel pump splined shaft and gearbox axis E shaftgear internal apline with grease.							
	petrolatum		VV-P-236			6-11	36
Comment: Lubricate preformed packing seal on afterburner fuel control and pump assembly with petrolatum.							
	antiseize compound		MIL-T-5544			6-13	6
Comment: Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.							
	petrolatum		VV-P-236			6-13	8
Comment: Lubricate fuel inlet manifold seals with petrolatum.							
	petrolatum		VV-P-236			6-13	29
Comment: Lubricate preformed packings on afterburner fuel pump with petrolatum.							
	antiseize compound		MIL-F-5544			6-13	30
Comment: Lubricate studs for the afterburner fuel pump with antiseize compound.							
	petrolatum		VV-P-236			6-15	22
Comment: Lubricate preformed packings for the afterburner high-pressure filter with petrolatum.							
	oil		MIL-L-7808			6-15	25
Comment: Apply oil to threads of afterburner high-pressure filter head.							
	petrolatum		VV-P-236			6-17	4
Comment: Lubricate new preformed packing for the afterburner fuel control filter with petrolatum.							
	oil		MIL-L-7808			6-17	6
Comment: Apply oil to threads of access plug for the afterburner fuel control filter.							
	oil		MIL-L-7808			6-20	7
Comment: Lubricate threads of all coupling nuts for the afterburner main fuel manifold with oil.							
	oil		MIL-L-7808			6-21	5
Comment: Lubricate threads of all coupling nuts for the afterburner pilot fuel manifold with oil.							
	oil		MIL-L-7808			6-21	36
Comment: Lubricate threads on afterburner main spraybar with oil.							
	oil		MIL-L-7808			6-22	20
Comment: Lubricate threads on afterburner pilot spraybar with oil.							

Current Practice is to use:	*Non-hazardous alternative*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		cleaning				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

	antiseize compound		MIL-T-5544			7-5	20
Comment:	Lubricate mounting studs on engine gearbox and all bolts and screws to be installed with the oil reservoir and oil pump w						
	petrolatum		VV-P-236			7-5	22
Comment:	Lubricate each preformed packing to be installed with the oil reservoir and oil pump with petrolatum.						
	antiseize compound		MIL-T-5544			7-5	33
Comment:	Lubricate mounting studs on oil pump with antiseize compound.						
	oil		MIL-L-7808			7-5	37
Comment:	Lubricate spline of oil pump and mating spline in engine gearbox with oil.						
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	antiseize compound		MIL-T-5544			7-6	8
Comment:	Apply antiseize compound to line connections on top of oil reservoir.						
	oil		MIL-L-7808			7-6A	15
Comment:	Before attaching oil cooler lines, lubricate connecting fittings with oil.						
	petrolatum		VV-P-236			7-6A	19
Comment:	Lubricate new preformed packings for the oil cooler installation with petrolatum.						
trichloroethane			O-T-620			7-8A	3
Comment:	Clean all parts in trichloroethane.						
	petrolatum		VV-P-236			7-9	19
Comment:	Lubricate new preformed packing for the oil filter with petrolatum.						
	petrolatum		VV-P-236			7-9	25
Comment:	Lubricate preformed packing for the oil pressure transmitter with petrolatum.						
	petrolatum		VV-P-236				
Comment:	Lubricate preformed packing and install on reducer fitting.						
Comment:	Engine serica # 243559 and later engines modified by T.O. 2J-J-85-675.						
	oil		MIL-L-7808			7-11	17-20 & 34
Comment:	Fill engine oil system with oil to the FULL mark on dipstick.						
Comment:	New warning note: Lube oil may contain tricresyl phosphate. This additive is poisonous and can be readily absorbed th						
Comment:	Ensure oil does not remain on skin. Oil may burn if exposed to heat or flames.						
Comment:	Neoprene gloves and face shield/safety goggles will be worn.						
	degreasing solvent		O-T-620 or equivalent			7-13	20
Comment:	Clean oil filter parts, except preformed pacckings and filter element, by washing in degreasing solvent.						
	solvent		P-D-680 Type II			8-4	24
Comment:	Use P-D-680 pressurized at 25 psig with shop air to blast-flush internal splines on the variable exhaust nozzle power unit.						
	oil		MIL-L-7808			8-4A	5

		lubrication				
ith antiseize.						
		lubrication				
		lubrication				
		lubrication				
Current Practice is to use:	*Non-hazardous alternative*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		servicing				
ough the skin.						
		cleaning				
		cleaning				
		lubrication				

Comment: Coat threads of studs for the variable exhaust nozzle power unit.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	8-4A	6
Comment: Lubricate the mating splines of the exhaust nozzle power unit and engine gearbox sparingly with grease.							
	antiseize compound				FSN 8030-664-6146	8-5	37
	graphite silicone grease		MIL-A-907			8-5	38
Comment: Coat threads of variable exhaust nozzle actuator attach bolts with antiseize compound or graphite silicone grease.							
	oil		MIL-L-7808			8-13	18
Comment: Service the variable exhaust nozzle power unit with oil until oil level is even with lower surface of oil check port.							
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
Comment: New warning note: Lube oil may contain tricresyl phosphate. This additive is poisonous and can be readily absorbed th							
Comment: Ensure oil does not remain on skin. Oil may burn if exposed to heat or flames.							
Comment: Neoprene gloves and face shield/safety goggles will be worn.							
	sealing compound		MIL-S-45180			9-5	15
Comment: Apply a small amount of sealing compound onto compressor casing bleed valve mounting flange.							
	antiseize compound		MIL-T-5544			9-5	17
Comment: Lubricate threads of all screws on the bleed valve assembly with antiseize compound.							
magnesium oxide	milk of magnesia				FSN 6505-684-8868	10-11	15
Comment: Lubricate threads of engine main igniter plug and lead coupling nut with milk of magnesia.							
Comment: This also applies to the engine afterburner igniter plug and ignition exciter.						10-12	6&27
	antiseize com	Ease-Off 990			FSN 8030-664-6146	10-11	36
	graphite silicone grease		MIL-A-907			10-11	37
Comment: Lubricate threads of four screws and two strap nuts with antiseize compound or graphite silicone grease.							
	dry lubricant		MIL-L-23398			10-21	10
	Oil		MIL-L-7808			12-9	17
Comment: Lubricate alternator-tachometer generator mounting studs.							
Comment: Spray valve butterfly and valve internal surface with dry lubricant.							
	petrolatum		FedSpecVV-P-236			12-11	23
Comment: Lubricate preformed packings.							
	insulation blankets and shrouds					12-12	16&34
Comment: Engine afterburner section.							
Magnesium oxide	Milk of magnesia				FSN 6506-684-8868	12-12	26
Comment: Lubricate diffuser bosses and harness coupling nuts with milk of magnesia.							
	hydraulic fluid		MIL-H-5606			13-7	35

		lubrication				
		lubrication				
		lubrication				
		servicing				
Current Practice is to use:	***Non-hazardous alternative***	***Type of Operation***	***Crew Size***	***Quantity***	***Time***	***Indiv Risk***
ough the skin.						
		sealing				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		insulation				
		lubrication				
		prime pump				

Comment:	Hydraulic fluid may contain tricresyl phosphate. This additive is poisonous and can be readily absorbed through the skin						
Comment:	Use neoprene gloves and make certain that this oil not remain on the skin. Use in a well ventilated area.						
Comment:	Avoid prolonged breathing of vapors. Avoid eye contact and repeated skin contact. Keep away from sparks and flam						
Comment:	*Prime hydraulic pump by filling pump case thru intake port with hydraulic fluid.*						
	solvent		P-D-680 Type II			13-11	21
Comment:	Installing AC generator.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	antiseize compound		MIL-T-5544			13-12	4
Comment:	Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-12	6
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	hydraulic fluid		MIL-H-5606			13-12	28
Comment:	Before installing hydraulic pump on accessory gearbox, prime pump with red fluid.						
	solvent		P-D-680 Type II			13-13	11
Comment:	Installing hydraulic pump.						
Comment:	*Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.*						
	antiseize compound		MIL-T-5544			13-13	22
Comment:	Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-13	24
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	solvent		P-D-680 Type II			13-19	37
Comment:	Installing Northrop airframe-mounted gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-20	11
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-20	13
Comment:	Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.						
	solvent		P-D-680 Type II			13-21	25
Comment:	Installing Bendix airframe-mounted gearbox power shaft coupling.						
Comment:	*Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.*						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-21	37
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-21	39

es.						
		cleaning				
		lubrication				
		lubrication				
Current Practice is to use:	***Non-hazardous alternative***	***Type of Operation***	***Crew Size***	***Quantity***	***Time***	***Indiv Risk***
		prime pump				
		cleaning				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				

Comment: Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb							
	solvent		P-D-680 Type II			13-22A	12
Comment: Installing Northrop engine gearbox power shaft coupling.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-23	11
Comment: Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.							
	antiseize compound		MIL-T-5544			13-23	13
Comment: Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb							
	solvent		P-D-680 Type II			13-26	10
Comment: Installing Bendix engine gearbox power shaft coupling.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	grease		MIL-G-81322			13-26	24
Comment: Lubricate engine power shaft coupling internal splines and engine gearbox axis B shaft gear (internal) splines with grease							
Chemical	***Known As***	***Commercial Name***	***Military Name***	***Reference***	***FSN***	***Page***	***Line***
	antiseize compound		MIL-T-5544			13-26	28
Comment: Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb							
	solvent		P-D-680 Type II			13-27	24
Comment: Replacing Northrop power shaft coupling quill shaft.							
Comment: Blast-flush internal splines using solvent pressurized at 25 psig with shop air.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-27	34
Comment: Lubricate coupling internal spline with grease.							
	lubricating oil		MIL-L-7808			13-28	23
Comment: Fill gearbox with oil using hand oil can. Fill gearbox until oil runs out of filler tube.							
Comment: New warning note: Lube oil may contain tricresyl phosphate. This additive is poisonous and can be readily absorbed th							
Comment: Ensure oil does not remain on skin. Oil may burn if exposed to heat or flames.							
Comment: Neoprene gloves and face shield/safety goggles will be worn.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-4	29
Comment: Apply a thin coat of zinc chromate putty to mating surface of cockpit throttle quadrant assembly.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-7	10
Comment: Apply a thin coat of zinc chromate putty to mating surfaces of engine bay cable quadrant.							
No lubricant listed.						14-9	18
Comment: Lubricate cable holes in pressure seals when installing throttle quadrant cables.							
	oil						
Comment: Oil leakage measured in drops per minute.							

ox.		cleaning				
		lubrication				
ox.		lubrication cleaning				
		lubrication				
Current Practice is to use:	***Non-hazardous alternative***	***Type of Operation***	***Crew Size***	***Quantity***	***Time***	***Indiv Risk***
ox.		lubrication cleaning				
		lubrication servicing				
ough the skin.						
		lubrication lubrication lubrication				
		troubleshooting				

Appendix B

Technical Order Automation

The following technical orders have been reviewed, and could be automated to facilitate review for identification of hazardous materials.

1F-5A-2-4	Pneudraulic Systems
1F-5A-2-5	Fuel Systems
1F-5A-2-7	Electrical Systems
1F-5A-2-8	Landing Gear Systems
1F-5A-2-10	Radio, Communication and Navigation Systems
1F-5A-2-11	Armament
1F-5A-17	Storage of Weapon Systems
1F-5A-33-1-1	Non Nuclear Munitions Basic Information
1F-5A-33-1-2	Non Nuclear Munitions Loading Procedures
XX1F-5A-2-2	Ground Handling, Storage, and Airframe Maintenance
XX1F-5A-2-3	Flight Control Systems
XX1F-5A-2-6	Powerplant
XX1F-5A-2-9	Instruments
XX1F-5A-3	Structural Repair
XX1F-5A-23	Corrosion Control
XX1F-5A-36	Non-Destructive Inspection
1F-5B-2-3	Flight Control Systems
1F-5B-2-4	Pneudraulic Systems
1F-5B-2-5	Fuel Systems
1F-5B-2-10	Radio, Communication and Navigation Systems
1F-5B-2-11	Armament
CSTO XX1F-5B-2-6	Powerplant
CSTO XX1F-5B-2-7	Electrical Systems
CSTO XX1F-5B-2-8	Landing Gear Systems
XX1F-5B-2-2	Ground Handling, Storage, and Airframe Maintenance
XX1F-5B-2-6	Powerplant
XX1F-5B-2-9	Instruments
NTM1F-5B-2-2(1)	Ground Handling, Storage, and Airframe Maintenance
NTM1F-5B-2-6(1)	Powerplant

NTM1F-5B-2-7(1)	Electrical Systems
NTM1F-5B-2-9(1)	Instruments
NTM1F-5B-2-10(1)	Radio, Communication, and Navigation Systems
NTM1F-5B-2-11(1)	Armament
NTM1F-5B-2-2(2)	Ground Handling, Storage, and Airframe Maintenance
NTM1F-5B-2-3(2)	Flight Control Systems
NTM1F-5B-2-4(2)	Pneudraulic Systems
NTM1F-5B-2-5(2)	Fuel Control Systems
NTM1F-5B-2-6(2)	Powerplant
NTM1F-5B-2-7(2)	Electrical Systems
NTM1F-5B-2-8(2)	Landing Gear Systems
NTM1F-5B-2-9(2)	Instruments
NTM1F-5B-2-10(2)	Radio, Communication, and Navigation Systems
NTM1F-5B-2-11(2)	Armament

Organizational Manuals

1F-5E-2-1-1	Airplane General
1F-5E-2-1-3	Cross Servicing Guide
1F-5E-2-12-1	Support Information, Part I
1F-5E-2-12-2	Support Information, Part II
1F-5E-2-2-3-2	Flight Control, Rudder System
1F-5E-2-20-5	Powerplant
1F-5E-3	Structural Repair
1F-5E/F-5F-23	Corrosion Control
1F-5E-33-1-1	Non Nuclear Munitions Basic Information
1F-5E-33-1-2	Non Nuclear Munitions Loading Procedures (Now SR1F-5E-33-1-2)
1F-5E-36	Non Destructive Maintenance
1F-5E-39	Aircraft Battle Damage Repair

Supplementary Technical Manuals

1F-5E(III)-2-1-1	Airplane General
1F-5E(III)-2-12	Support Information
1F-5E(III)-23	Corrosion Control
1F-5E(III)-33-1-1	Non Nuclear Munitions Basic Information
1F-5E(III)-33-1-2	Non Nuclear Munitions Loading Procedures
1F-5F-2-1-1	Airplane General
1F-5F-2-12-1	Support Information, Part I
1F-5F-2-12-2	Support Information, Part II

Appendix C

The Environmental Protection Agency List of 17 Toxics

1. Benzene
2. Chromium
3. Lead
4. Methyl Ethyl Keytone
5. Methylene Chloride
6. Perchloroethylene
7. Cyanides
8. Toluene
9. Trichloroethane
10. Xylene
11. Cadium
12. Carbon Tetrachloride
13. Chloroform
14. Mercury
15. Methyl Isobutyl Keytone
16. Nickel
17. Trichloroethylene

Appendix B: F-5 Technical Order Data Base for Hazardous Materials

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: December 1992**
T.O. 1F-5A-2-1 ***General Airplane***
Basic: 1 Aug 70 through Change 14: 15 Aug 87

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*
	hydraulic fluid		MIL-H-83282	T.O. 1F-5A-2-2	FSN XXXX-XXX-XXXX	1-46
	hydraulic fluid		MIL-H-5606	T.O. 1F-5A-2-2		1-46
	fuel	JP-4	MIL-T-5624	T.O. 1F-5A-2-5		2-2A
Comment: *Internal fuel is contained in five internal bladder-type fuel cells in the fuselage center section. Total usable fuel capac*						
Comment: A 50 gallon tank can be used at each wingtip; a 150 gallon droppable tank can be attached to left and right wing st						
	engine oil		MIL-L-7808	T.O. 1F-5A-2-2 &		2-4
				T.O. 1F-5A-2-6		5-1
	liquid oxygen		MIL-O-27210 Type II	T.O. 1F-5A-2-2 &		2-2A
				T.O. 1F-5A-2-4		4-9
nickel-cadmium	aircraft battery			T.O. 8D2-3-1		2-4
nitrogen						
	rain repellent			T.O. 1F-5A-2-2 &		2-5
				T.O. 1F-5A-2-4		4-10
Comment: (a solution of a proprietary repellent formulation supplied in throwaway-type aerosol containers pressurized with nitrog						
	lubricants			T.O. 1F-5A-2-2		2-5
	(fuselage)			T.O. 1F-5A-2-2		3-1
aluminum alloy	(skins)			T.O. 1F-5A-2-2		3-1
magnesium	(high-temp areas)			T.O. 1F-5A-2-2		3-1
steel	(high-temp areas)			T.O. 1F-5A-2-2		3-1
titanium						

LAST ENTRY

Line	*Current Practice is to use:*	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
30			servicing		2@1.25 US gals		
30			servicing		2@1.25 US gals		
legend			servicing		583 gals		
ity = 583 gallons.							
ation pylons, or a 150 gallon droppable centerline tank can be used.							
6			servicing		2@4qts ea		
31					(3.7 to 5.6 qts)		
legend			servicing		5 liters		
16							
37			servicing				
			servicing				
20			servicing				
3							
en gas)							
26			servicing				
3							
3							
5							
5							

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: December 1992**
T.O. 1F-5A-2-2 *Ground Handling, Servicing, and Airframe Maintenance*
Basic: 1 Aug 70 through Change 33: 15 May 89

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*
	hydraulic fluid		MIL-H-83282			1-46
			MIL-H-5606			1-46
Comment: Insure support equipment used to service/perform maintenance has the same type of fluid as that in the aircraft.						
	hydraulic fluid					2-63
						3-34
Comment: Clean landing gear shock struts and pistons with a clean cloth soaked with hydraulic fluid.						4-1
	kerosene					2-63
						3-34
Comment: Use kerosene as a solvent to remove dirt and grit on landing gear shock struts and pistons.						
ethylene glycol-propylene glycol	anti-icing and deicing fluid		MIL-A-8243A			2-65
Comment: Anti-icing and deicing fluid is used to prevent the accumulation of frozen deposits on surfaces of aircraft while on the gr						
Comment: Fluid may flash at temperatures above 200 degrees F.						
Comment: Fluid is mildly toxic and personnel should avoid contact with skin or eyes.						
Comment: Fluid may be diluted with equal parts by volumn of water and heated to a temperature of 80 to 100 degrees F.						
Comment: Do not use fluid full strength. It will damage painted surfaces.						
Comment: Heated fluid should be applied at pressures as high as possible but not over 100 to 125 psi on metal surfaces.						
isopropyl alcohol						2-65
Comment: A mixture of equal parts of isopropypl alcohol and water should be used alternately with MIL-A-8243A defrosting fluid.						
	fire extinguisher		MIL-E-26243 Type FEU1M		FSN 4210-203-5361	2-68
Comment: Vaporizing liquid fire extinguisher. Used to provide standby fire protection.						
	JP-4 fuel	NATO F-40	MIL-T-5624			3-3
Comment: Left fuel system.						
	JP-4	NATO F-40	MIL-T-5624			3-3
Comment: Right fuel system.						
	JP-4	NATO F-40	MIL-T-5624			3-3
Comment: Centerline pylon tank.						

Line	Current Practice is to use:	Other "Suitable Substitutes":	Type of Operation	Crew Size	Quantity	Time	Indiv Risk
31							
31							
33			cleaning				
29							
18							
34			cleaning				
30							
			anti-icing				
27			deicing				
	ound or to remove accumulated deposits.						
34			deicing				
11			fire extinguisher				
4			servicing		293 US gals		
6			servicing		305 US gals		
11			servicing		152 US gals		

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page
	JP-4	NATO F-40	MIL-T-5624			3-3
Comment: Two wing pylon tanks						
	JP-4	NATO F-40	MIL-T-5624			3-3
Comment: Two wingtip tanks						
	hydraulic fluid	NATO H-537	MIL-H-83282			3-3
Comment: Utility hydraulic system; left reservoir.						3-29
Comment: MIL-H-83282 is a synthetic hydrocarbon base hydraulic fluid with an oxidation inhibitor, and an antiwear agent (tricresyl						
	hydraulic fluid	NATO H-537	MIL-H-83282			3-3
Comment: Flight control hydraulic system; right reservoir.						3-29
Comment: MIL-H-83282 is a synthetic hydrocarbon base hydraulic fluid with an oxidation inhibitor, and an antiwear agent (tricresyl						
	oil	NATO O-148	MIL-L-7808	T.O. 42B2-1-1		3-3
Comment: Accessory drive gearbox; left and right gearboxes.						3-53
	oil	NATO O-148	MIL-L-7808	T.O. 42B2-1-1		3-3
				T.O. 00-25-172		3-26A
Comment: Engine oil; left and right engine-mounted oil reservoirs.						
	liquid oxygen		MIL-O-27210			
			Type II (liquid)			3-3
Comment: Breathable oxygen.						
Comment: Personnel required to fill or drain the liquid oxygen system must become familiar with T.O. 15X-1-1, T.O. 42B6-1-1, and T.O.						
	oil		MIL-L-6085A			3-3
Comment: Air conditioning unit; turbine oil sump.						3-54
Comment: Fill until oil runs out of both sump plug holes.						
				T.O. 4S-1-182		3-12
Comment: Prior to refueling the aircraft, clean the exposed chrome portion of landing gear struts in accordance with T.O. 4S-1-182.						
	fuel/water					3-25
Comment: A quantity of residual fuel is drained from the service drain to check fuel supply for water and other contaminants.						
	solvent		P-D-680			3-26
Comment: Procedure to clean fuel strainer element.						
	preservative oil		MIL-H-6083			3-32
Comment: Replacement landing gear shock struts are furnished with preservative oil. Do not drain preservative oil when servicing s						
nitrogen	dry nitrogen		MIL-N-6011			3-34
Comment: Use only approved nitrogen or clean dry air to inflate shock struts.						
tetrafluoroethylene	tape		MIL-T-27730			3-37
Comment: Use only tetrafluoroethylene tape for oxygen system tapered pipe threads.						

Line	Current Practice is to use:	Other "Suitable Substitutes":	Operation	Crew Size	Quantity	Time	Indiv Risk
13			servicing		2@304 US gals		
15			servicing		2@99 US gals		
17			servicing		1.25 US gals		
26 phosphate).							
19			servicing		1.25 US gals		
26 phosphate).							
21			servicing		2@44 ounces		
22							
23			servicing		2@1 US gal		
33							
27			servicing		5 liters		
00-25-172.							
29			servicing				
12							
30			cleaning				
13			draining fuel				
43			cleaning				
12 fruits.			preserving				
5			servicing				
43			servicing				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page
nickel-cadmium	ni-cad battery			T.O. 1F-5A-2-7		3-51
Comment: The battery is a 19-cell 24-volt 11-ampere-hour nickel-cadmium battery.						
	solvent		P-D-680			3-53
Comment: Clean gearbox drainplug by washing in solvent. Use clean dry air at 29 psi or less to remove solvent.						
	petrolatum		VV-P-236			3-57
Comment: Lubricate water separator preformed packing and reinstall on outer periphery of screen disk.						
Freon 113 and silicone-titanate copolymer	rain repellent fluid					3-59
Comment: Removal of rain repellent fluid container.						
Comment: Once the retaining torque on the container has been broken, the container must be unscrewed as rapidly as possible t						
Comment: Avoid contact of rain repellent fluid with skin or prolonged breathing of vapors.						
Freon 113	solvent or repellent					3-60
Comment: Placle removed rain removal system nozzles in Freon 113 and allow to soak until buildup has dissolved.						
		Mirror Glaze Machine Light Cleaner	PN MGM-2			3-61/3-62
Comment: Use this product to remove rain repellent fluid residue from aircraft windshield.						
	cleaning compound		MIL-C-18767			3-61/3-62
Comment: Use this product if the Mirror Glaze Machine Light Cleaner is not available.						
	grease		MIL-G-81322			4-1
Comment: Be sure new wheel cones and rollers are packed with grease before installation.						4-26
Comment: Do not use different types of grease in the same wheels: this grease is not compatible with petroleum base lubricants.						
methyl ethyl ketone (mek)	MEK					5-20A
Comment: MEK is discribed but not required for anything on this page.						
alum oxide	grit					5-20A
Comment: Remove all baked on dry film lubricant from new bolts with dry grit blast with 120 grit alum oxide.						
	solid film lubricant		MIL-S-22473, grade N or T, form R			5-20A
Comment: Apply cleaner primer to 15% spar attach bolt.						
	type III loctite		MIL-R-46082			5-20A
Comment: Apply loctite to 15% spar attach bolt.						5-23
	type II loctite		MIL-T-46082			7-3
Comment: Apply loctite to grounding receptacle hex nut.						

Line	Current Practice is to use:	Other "Suitable Substitutes":	Operation	Crew Size	Quantity	Time	Indiv Risk
19			servicing				
8			cleaning				
6			lubrication				
6			servicing				
) prevent excessive fluid spillage.							
31			cleaning				
8			cleaning				
10			cleaning				
36			lubrication				
10,14,16							
4							
27			cleaning				
34			lubrication				
35			maintenance				
18							
24			maintenance				

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*
aliphathic naphtha	cleaner			T.O. 1-1A-12		8-2
Comment: Aliphathic naphtha may be used as a cleaner for acrylic windwhield panels. It should not be confused with aromatic n						
	sealant			T.O. 1F-5A-3		8-9
Comment: Seal any gap at ends of windshield pneumatic seal and frame channel with sealant.						
	preservative			T..O. 1F-5A-3		8-9
						9-61
Comment: To retard deterioration of the pneumatic windshield seal, apply a preservative.						
				T.O. 1F-5A-3		8-14
Comment: Pickle all filed edges of the magnesium windshield frame in accordance with T.O. 1F-5A-3.						
	glyptal enamel	S-8493 RED				9-14
		Fuller Paint Co				10-8
		1201 RED				
		General Electric Co.				
Comment: Seal canopy jettison mechanism setscrews with glyptal enamel.						
	primer	Locquic Grade Q				9-67
Comment: Clean mating surfaces of thruster rod end and threster threads with primer.						
	sealant	Loctite AV(10-10)				9-67
Comment: Apply sealant to canopy jettison thruster threads.						
naptha	cleaner		TT-N-95			9-91
Comment: Clean mating surfaces of shaft and lock crank on canopy locking mechanism with naphtha.						
	epoxy	Epon 815 adhesive				9-91
		T-1 curing agent				
Comment: Apply mixture of adhesive and curing agent to mating surfaces of shaft and lock crank.						
	putty	Kem-Weld putty	Resin D2S-8	T.O. 1F-5A-3		9-95
		Kem-Weld hardener	D2T-9			9-108
Comment: Fill slot in lock housing below shim with Kem-Weld putty.						
Comment: The area between the switch actuator arm and the crank must be filled with Kem Weld.						
	sealant	Loctite Grade H (1-1)				10-5
						10A-5
Comment: If unused electrical connector adapters are loose, apply a small amount of Loctite to threads.						
zinc chromate	zinc chromate					10-A-5
Comment: Paint handgrip retention slot with zinc chromate after filing.						
FINAL ENTRY						

Line	Current Practice is to use:	Other "Suitable Substitutes":	Operation	Crew Size	Quantity	Time	Indiv Risk
15 aphtha.			cleaning				
12			maintenance				
14			maintenance				
14							
33			maintenance				
19			painting				
18							
42			cleaning				
43			sealing				
11			cleaning				
12			sealing		100 parts 20 parts		
5			sealing		45 parts		
24					55 parts		
19			sealing				
20							
38			painting				

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: December 1992**
T.O. 1F-5A-2-4 ***Pneudraulic Systems***
Basic: 1 Aug 70 through Change 19: 15 June 85

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	hydraulic fluid		MIL-H-83282			2-1	14
Comment: This hydraulic fluid is a synthetic hydrocarbon base fluid with an ocidation inhibitor, and an antiwear agent (tricresyl phosphat							
	oil		MIL-L-7808 or MIL-H-5606			2-3	5
Comment: Lubricate mating surfaces on hoses and tubes with light oil.							
	petrolatum		VV-P-236			2-3	11
						2-3	17
						2-3	21
Comment: Lubricate preformed packing, and bulkhead fitting end with petrolatum.							
	petrolatum, technical		VV-P-236			2-9	37
Comment: Light, semisolid material composed of petroleum waxws and oil.							
Comment: *Melting point: 117 to 140 degrees F.*							
Comment: May be used in small quantities for electrical or hydraulic connections.							
	antiseize compound, white lead base		JAN-A-669			2-10	5
Comment: General purpose antiseize and sealing compound for threaded parts.							
Comment: Thick paste composed of white lead (60%), graphite (10%), petrolatum (10%), mineral oil (10%), and asphalt (10%).							
Comment: Contact with air causes moderate hardening.							
Comment: Used for all types of threaded connections for pressures up to 150 psi and for temperatures up to 350 degrees F.							
tetrafluoroethylene	Teflon tape		MIL-T-27730			2-10	13
						2-21	5
						10-5	12
Comment: Pure Teflon ribbon tape suitable for oxygen system connections.							
Comment: May be used for thread sealant antiseize purposes on liquid and gaseous oxygen systems.							
Comment: Teflon tape is the only sealant and antiseize agent that may be used in oxygen system connections.							
	antiseize compound, graphite-petrolatum		MIL-T-5544			2-10	22
Comment: Heavy paste composed of 50% graphite and 50% petrolatum.							
Comment: Suitable as an antiseize compound for elevated temperature (350-1200 degrees F).							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*	*Env Risk*
e).		servicing					
		lubrication					
		lubrication					
		maintenance					
		maintenance					
		maintenance					

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
Comment: Not generally suitable where good sealing properties are required.							
Comment: Graphite content (conducting material) necessitates discretion in use for electrical systems.							
	hydraulic oil		MIL-H-83282			2-10	29
Comment: Operating oil for aircraft hydraulic systems and landing gear shock struts.						11-36	10
Comment: Effective 1 November 1981, MIL-H-83282 became the preferred hydraulic fluid. MIL-H-5606 may, to prevent grounding, be mix							
Comment: Should be used in preference to petrolataum as an antiseize and sealant material for all hydraulic system connections.							
	zinc chromate putty		MIL-P-8116			2-10	37
Comment: Heavy zinc chromate compound to be used for corrosion prevention in threaded connections between dissimilar metals;							
Comment (con't) magnesium connections, aluminum with unplated steel, copper, brass, or bronze.							
	carbon remover		MIL-C-25107	T.O. 9H3-1-1		2-19	19
Comment: Toxic material. Adequate exhaust ventilation must be in operation at all times while this material is in use. Avoid inhalation an							
Comment: Protective clothing including eye shields, rubber safety-toed shoes, plastic covered aprons, and rubber gloves must be worn b							
trichlorethylene	trich		O-T-634A	T.O. 9H3-1-1		2-19	19
Comment: Toxic material. Adequate exhaust ventilation must be in operation at all times while this material is in use. Avoid inhalation an							
Comment: Protective clothing including eye shields, rubber safety-toed shoes, plastic covered aprons, and rubber gloves must be worn b							
	form-a-gasket sealant			T.O. 1F-5A-3		4-12 4-14	5 7
Comment: Apply form-a-gasket sealant to station 194 bulkhead in accordance with T.O. 1F-5A-3.							
				T.O. 1F-5A-2-11		9-12	26
Comment: No specific materials listed.							
Comment: During removal and replacement of any parts in the gun gas deflector system, it is important that cleaning instructions in T.O.							
	spray lubricant		MIL-L-23398			9-18	18
Comment: Lubricate all bearing surfaces of spring guide, spring guide assembly, and spring with spray lubricant.							
	leak test compound		MIL-L-25567			10-5	15
Comment: When checking oxygen system for leaks, use only approved leak test compound.						10-7	33, 39
Comment: Use extreme care when applying leak test compound to face of oxygen filler valve to prevent compound from running into v							
	hydraulic fluid		MIL-H-83282			11-24B	8,11
Comment: To test temperature probe, it is submerged in hydraulic oil heated to 230 to 250 degrees F.							
Comment: When handling hot oil, wear special clothing, including face mask, gloves, and apron.							
	antiseize compound		MIL-T-5544A			11-29	23
Comment: To reduce the possibility of seizure, apply a thick coating of antiseize compound to the filter nut before installing the reservoir p							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*	*Env Risk*
		maintenance					
)d with MIL-H-83282.							
		maintenance					
		cleaning					
d skin contact. y personnel handling this material.							
		cleaning					
d skin contact. y personnel handling this material.							
		maintenance					
		cleaning					
F-5A-2-11 be followed.							
		lubrication					
)ive.							
		maintenance					
		maintenance					
ressurization air filter element.							

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	solvent		P-D-680			11-30B	13
Comment: Clean sight gage glass with solvent P-D-680 or equivalent.							
	clear lacquer		MIL-L-19537			11-30B	20
Comment: Seal edges of temperature tape with clear lacquer.							
	rain repellent fluid					12-1	11
Comment: Repellent fluid is a proprietary formulation supplied in throwaway type aerosol containers pressurized with nitrogen gas.							
Comment: Installation, removal, and residue clean-up are covered in T.O. 1F-5A-2-2.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*	*Env Risk*
		cleaning					
		painting					
		maintenance					

F-5A Hazardous Materials Risk Analysis
Developed by: Capt Janice M. Gavern **Current as of: December 1992**
T.O. 1F-5A-2-6 ***Powerplant***
Basic: 1 May 1971 through Change 15: 1 March 1986

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	hydraulic fluid		MIL-H-83282 or MILL-H-5606			1-46	31
Comment: Maintenance personnel use a hydraulic test stand to provide external hydraulic power tto operate the various aircraft sy							
Comment: Personnel may be exposed to spillage.							
	petrolatum		VV-P-236			2-4	24
Comment: Apply to preformed packings.							
	lubricating oil		MIL-L-7808	T.O. 42B2-1-1		2-4	27
Comment: Lubricate packing grooves, lead-in chamfers, bores, and outside diameters over which preformed packings must pass.							
Comment: Page 2-4A and 2-5 contain a chart listing engine lubricants.							
	preservative			T.O. 2J-J85-66-1		3-100	9
Comment: Ensure that the engine has been preserved before removal of quick engine change components.							
	calibration fluid		MIL-F-7024			3-100L	13
Comment: If fuel flowmeter is to be stored, ensure that flowmeter is filled with calibration fluid to protect internal parts.							
	spray lube	Lubri-Bond			FSN 9150-754-0064	3-103	3
Comment: Lubriciate trunnion mount balls with Lubri-Bond spray lube.							
	graphite grease		MIL-G-21164			3-110	11
Comment: Coat internal mating surfaces of the throttle control quick-disconnect rod with a thin film of graphite grease.							
	spray lube	Lubri-Bond A	MIL-L-23398			3-111	13
Comment: Lubricate preformed packing groove and inner surface of right half (of slip-joint coupler) with Lubril-Cond A.							
	lubricating oil		MIL-L-7808			3-116	8
Comment: Coat all afterburner attach bolts with lubricating oil.							
	antiseize com	Jet-lube SS-30 (Hi-Temp)			FSN 8030-180-6315	3-119 &	16
Comment: Before installing manifold, coat attach bolt threads with Jet-Lube SS-30 (Hi-Temp).						3-121	22
	petrolatum		VV-P-236			3-127	26
Comment: Lubricate preformed packing (on fuel flowmeter transmitter) with petrolatum.							
	petrolatum		VV-P-236			3-129	20
Comment: Lubricate seals (on fuel inlet manifold mounting studs) with petrolatum.							
	oil		MIL-L-25681			3-132	4
Comment: Lubricate remote speed control cables with oil.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
stems.		maintenance				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	vapor degrease			T.O. 2J-1-13		3-148	9
Comment: Vapor degrease parts in accordance with Process 1, T.O. 2J-1-13.							
	acetone		O-A-51			3-148	27
Comment: Rinse parts in clean reagent grade acetone, and air dry.							
	solid film lubricant				FSN 9150--964-9228	3-148	32
Comment: Use Solid Film Lubricant to lubricate parts.					FSN 9150-964-9244		
				T.O. 1F-5A-3		3-152	5
Comment: The engine bay firewalls must be cleaned at prescribed intervals to prevent buildup of residue.							
	high-temperature sealant			T.O. 1F-5A-3		3-152	7
Comment: If any firewall access panels are removed the panels must be resealed with high-temperature sealant.							
		Rust-Lick No. 606		T.O. 2J-J185-102		3-153	6
Comment: Clean the engine compressor section using reverse Rust-Lick and water-wash.							
	corrosion prev	WD-40		T.O. 2J-J85-102		3-153	19
Comment: Use only WD-40 or Rust-Lick No. 606 to preserve engine. Do not mix WD-40 and Rust-Lick.							
	insulation blanket					4-4	21
Comment: This is the compressor casing insulation blanket.							
	antiseize com	Ease-Off 990			FSN 8030-664-6146	4-44	6
	graphite silicone grease		MIL-A-907		FSN 9150-735-1800	4-44	7
Comment: Lubricate threads on flexible drive shaft coupling nuts with antiseize compound or graphite silicone grease.							
	oil		MIL-L-7808			5-8	8
Comment: All line fittings on fuel control should be lubricated with oil.							
	solvent		P-D-680 Type II			5-8	25
Comment: Clean gearbox axis D shaftgear internal splines with P-D-680 Type II pressurized at 25 psig with shop air.							
	grease	Plasti-lube Moly No.3			FSN 9150-823-0845	5-8	35
Comment: Lubricate pump splined shaft and gearbox axis D internal spline sparingly with grease.							
	antiseize compound		MIL-T-5544			5-8	37
Comment: Lubricate threads of the four studs on engine gearbox mounting pad with antiseize compound.							
	antiseize compound		MIL-T-5544			5-10	14
Comment: Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.							
	petrolatum		VV-P-236			5-10	16
Comment: Lubricate fuel inlet manifold seals with petrolatum.							
	petrolatum		VV-P-236			5-10	36
Comment: Lightly lubricate the three preformed packings (on the main fuel pump) with petrolatum.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		cleaning				
		cleaning				
		lubrication				
		cleaning				
		resealing				
		cleaning				
		preserving		4 ozs		
		maintenance				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			5-10	39
Comment:	Lubricate studs (for the main fuel pump) with antiseize compound.						
	petrolatum					5-10A	14
Comment:	Lubriciate packing (for the high pressure relief valve cover) with petrolatum before installation.						
	antiseize com	Ease-Off 990			FSN 8030-664-6146	5-11	15
	graphite silicone grease		MIL-A-907			5-11	16
Comment:	Lubricate threads on the four bolts (on the main fuel nozzel) with antiseize compound or graphite silicone grease.						
	petrolatum		VV-P-236			5-13	35
Comment:	Lubricate preformed packing (main fuel control filter) with petrolatum.						
	oil		MIL-L-7808			5-13	37
Comment:	Apply oil to threads of access plug (main fuel control filter).						
	petrolatum		VV-P-236			5-15	10
Comment:	Lubricate new preformed packing (main fuell pump filter) with petrolatum.						
	oil		MIL-L-7808			5-15	12
Comment:	Apply oil to threads of cap and spring assemble on the main fuel pump filter.						
	solvent		P-D-680 Type II			5-18	12
Comment:	Using solvent P-D-680 pressurized at 25 psi with shop air, blast-flush internal splines on the overspeed governor.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	5-18	28
Comment:	Lubricate mating splines on governor and gearbox with grease.						
	degreasing solvent		O-T-634			5-19	24
Comment:	This procedure uses an ultrasonic cleaning unit. If one is not available, clean filter elements in accordance with T.O. 2J-1						
Comment:	Clean filter parts except preformed packings and filter element by washing in degreasing solvent.						
Comment:	This procedure also applies to the oil filter parts.						
	carbon remover compound		MIL-C-25107			5-19	27
Comment:	Soak filter element for 30 minutes in carbon remover compound before placing element in ultrasonic cleaning unit.						
Comment:	This procedure also applies to the oil filter element.					7-13	30
	cleaning fluid		P-C-111			5-19	31
			P-C-436			5-19	31
Comment:	Place filter element into steel basket in ultrasonic cleaning tank for one hour.						
Comment:	This procedure applies to the main fuel control filter and to the main fuel pump filter.						
Comment:	It also applies to the afterburner high-pressure filter and the afterburner fuel control filter.						
Comment:	It also applies to the oil filter element.					7-13	35
	solvent		P-D-680 Type II			6-12	13
Comment:	Use P-D-680, pressurized at 25 psig, to blast-flush internall splines on the afterburner fuel control and pump assembly.						

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubricate				
		cleaning				
13.						
		cleaning				
		cleaning				
		cleaning				
		cleaning				
		cleaning				
		cleaning				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	oil		MIL-L-7808			6-12	32
Comment: All line fittings on the fuel control should be lubricated with oil.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	6-12	35
Comment: Lubricate afterburner fuel pump splined shaft and gearbox axis E shaftgear internal apline with grease.							
	petrolatum		VV-P-236			6-12	36
Comment: Lubricate preformed packing seal on afterburner fuel control and pump assembly with petrolatum.							
	antiseize compound		MIL-T-5544			6-13	39
Comment: Lubricate threads of fuel inlet manifold mounting studs with antiseize compound.							
	petrolatum		VV-P-236			6-13	41
Comment: Lubricate fuel inlet manifold seals with petrolatum.							
	petrolatum		VV-P-236			6-14	20
Comment: Lubricate preformed packings on afterburner fuel pump with petrolatum.							
	antiseize compound		MIL-F-5544			6-14	22
Comment: Lubricate studs for the afterburner fuel pump with antiseize compound.							
	petrolatum		VV-P-236			6-16	14
Comment: Lubricate preformed packings for the afterburner high-pressure filter with petrolatum.							
	oil		MIL-L-7808			6-16	17
Comment: Apply oil to threads of afterburner high-pressure filter head.							
	petrolatum		VV-P-236			6-16	32
Comment: Lubricate new preformed packing for the afterburner fuel control filter with petrolatum.							
	oil		MIL-L-7808			6-16	34
Comment: Apply oil to threads of access plug for the afterburner fuel control filter.							
	oil		MIL-L-7808			6-20	7
Comment: Lubricate threads of all coupling nuts for the afterburner main fuel manifold with oil.							
	oil		MIL-L-7808			6-20	26
Comment: Lubricate threads of all coupling nuts for the afterburner pilot fuel manifold with oil.							
	oil		MIL-L-7808			6-20A	22
Comment: Lubricate threads on afterburner main spraybar with oil.							
	oil		MIL-L-7808			6-20A	37
Comment: Lubricate threads on afterburner pilot spraybar with oil.							
	antiseize compound		MIL-T-5544			7-6	20
Comment: Lubricate mounting studs on engine gearbox and all bolts and screws to be installed with the oil reservoir and oil pump w							
	petrolatum		VV-P-236			7-6	22
Comment: Lubricate each preformed packing to be installed with the oil reservoir and oil pump with petrolatum.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
ith antiseize.		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			7-6	33
Comment: Lubricate mounting studs on oil pump with antiseize compound.							
	oil		MIL-L-7808			7-6	37
Comment: Lubricate spline of oil pump and mating spline in engine gearbox with oil.							
	antiseize compound		MIL-T-5544			7-7	12
Comment: Apply antiseize compound to line connections on top of oil reservoir.							
	oil		MIL-L-7808			7-8	8
Comment: Before attaching oil cooler lines, lubricate connecting fittings with oil.							
	petrolatum		VV-P-236			7-8	12
Comment: Lubricate new preformed packings for the oil cooler installation with petrolatum.							
trichloroethylene	tric		O-T-634			7-10	12
Comment: Clean all parts of the oil filter assembly with trichloroethylene.							
	petrolatum		VV-P-236			7-10	30
Comment:Lubricate new preformed packing for the oil filter with petrolatum.							
	petrolatum		VV-P-236			7-11	10
Comment: Lubricate preformed packing for the oil pressure transmitter with petrolatum.							
	oil		MIL-L-7808			7-13	4
Comment: Fill engine oil system with oil to the FULL mark on dipstick.							
	degreasing solvent		O-T-634			7-13	27
Comment: Clean oil filter parts, except preformed packings and filter element, by washing in degreasing solvent.							
	solvent		P-D-680 Type II			8-4A	30
Comment: Use P-D-680 pressurized at 25 psig with shop air to blast-flush internal splines on the variable exhaust nozzle power unit.							
	oil		MIL-L-7808			8-6	5
Comment: Coat threads of studs for the variable exhaust nozzle power unit.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	8-6	6
Comment: Lubricate the mating splines of the exhaust nozzle power unit and engine gearbox sparingly with grease.							
	antiseize compound				FSN 8030-664-6146	8-6	38
	graphite silicone grease		MIL-A-907			8-6	38
Comment: Coat threads of variable exhaust nozzle actuator attach bolts with antiseize compound or graphite silicone grease.							
	oil		MIL-L-7808			8-13	8
Comment: Service the variable exhaust nozzle power unit with oil until oil level is even with lower surface of oil check port.							
	sealing compound		MIL-S-45180			9-5	12
Comment: Apply a small amount of sealing compound onto compressor casing bleed valve mounting flange.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		servicing				
		cleaning				
		cleaning				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		servicing				
		sealing				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	antiseize compound		MIL-T-5544			9-5	14
Comment: Lubricate threads of all screws on the bleed valve assembly with antiseize compound.							
magnesium oxide	milk of magnesia				FSN 6505-684-8868	10-12	8
Comment: Lubricate threads of engine main igniter plug and lead coupling nut with milk of magnesia.							
Comment: This also applies to the engine afterburner igniter plug and ignition exciter.						10-20	3, 24
	antiseize com	Ease-Off 990			FSN 8030-664-6146	10-12	31
	graphite silicone grease		MIL-A-907			10-12	32
Comment: Lubricate threads of four screws and two strap nuts with antiseize compound or graphite silicone grease.							
	dry lubricant		MIL-L-23398			10-21	3
	Oil		MIL-L-7808			12-9	21
Comment: Lubricate alternator-tachometer generator mounting studs.							
	petrolatum		FedSpecVV-P-236			12-11	23
Comment: Lubricate preformed packings.							
	insulation blankets and shrouds					12-12	17
Comment: Engine afterburner section.							
Magnesium oxide	Milk of magnesia				FSN 6506-684-8868	12-12	28
Comment: Lubricate diffuser bosses and harness coupling nuts with milk of magnesia.							
	hydraulic fluid		MIL-H-5606			13-7	36
Comment: Prime hydraulic pump by filling pump case thru intake port with hydraulic fluid.							
	solvent		P-D-680 Type II			13-12A	40
Comment:Installing AC generator.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	antiseize compound		MIL-T-5544			13-13	22
Comment: Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.							
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-13	24
Comment: Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.							
	hydraulic fluid		MIL-H-5606			13-14	7
Comment: Before installing hydraulic pump on accessory gearbox, prime pump with red fluid.							
	solvent		P-D-680 Type II			13-14	25
Comment: Installing hydraulic pump.							
Comment: Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.							
	antiseize compound		MIL-T-5544			13-14	36
Comment: Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		lubrication				
		insulation				
		lubrication				
		prime pump				
		cleaning				
		lubrication				
		lubrication				
		prime pump				
		cleaning				
		lubrication				

Chemical	Known As	Commercial Name	Military Name	Reference	FSN	Page	Line
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-14	38
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	solvent		P-D-680 Type II			13-20	19
Comment:	Installing Northrop airframe-mounted gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-20	31
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-20	33
Comment:	Apply a thin coat of antiseize compound to both sides of new gasket and install gasket on gearbox.						
	solvent		P-D-680 Type II			13-21	42
Comment:	Installing Bendix airframe-mounted gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-22	10
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-21	12
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-23	25
Comment:	Installing Northrop engine gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-23	38
Comment:	Lubricate gearbox internal spline and fill relief cavity in back of spline 1/2 full with grease.						
	antiseize compound		MIL-T-5544			13-23	40
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-25	36
Comment:	Installing Bendix engine gearbox power shaft coupling.						
Comment:	Blast-flush internal splines and spline relief cavity using solvent pressurized at 25 psig with shop air.						
	grease		MIL-G-81322			13-26	9
Comment:	Lubricate engine power shaft coupling internal splines and engine gearbox axis B shaft gear (internal) splines with grease						
	antiseize compound		MIL-T-5544			13-26	13
Comment:	Apply a thin coat of antiseize compound to both faces of gasket; position gasket and power shaft coupling onto gearb						
	solvent		P-D-680 Type II			13-28	17
Comment:	Replacing Northrop power shaft coupling quill shaft.						
Comment:	Blast-flush internal splines using solvent pressurized at 25 psig with shop air.						

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		cleaning				
		lubrication				
		lubrication				
		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				
		lubrication				
		lubrication				
ox.		cleaning				

Chemical	*Known As*	*Commercial Name*	*Military Name*	*Reference*	*FSN*	*Page*	*Line*
	grease	Plastilube Moly No. 3			FSN 9150-823-8045	13-28	27
Comment: Lubricate coupling internal spline with grease.							
	lubricating oil		MIL-L-7808			13-29	4
Comment: Fill gearbox with oil using hand oil can. Fill gearbox until oil runs out of filler tube.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-4	33
Comment: Apply a thin coat of zinc chromate putty to mating surface of cockpit throttle quadrant assembly.							
zinc chromate	zinc chromate putty		MIL-P-8116			14-6	30
Comment: Apply a thin coat of zinc chromate putty to mating surfaces of engine bay cable quadrant.							
No lubricant listed.						14-8	26
Comment: Lubricate cable holes in pressure seals when installing throttle quadrant cables.							
	oil					15-78	17
Comment: Oil leakage measured in drops per minute.							

Current Practice is to use:	*Other "Suitable Substitutes":*	*Type of Operation*	*Crew Size*	*Quantity*	*Time*	*Indiv Risk*
		lubrication				
		servicing				
		lubrication				
		lubrication				
		lubrication				
		troubleshooting				
.....						

Appendix C: Definitions

The following words, defined here (23:Appendix 2; 33), have been used throughout this document. They are summarized for the convenience of the reader.

AFMC Targeted Substances. AFMC targeted substances are the EPA-17 substances and isocyanate HMDI and trichlorotrifluoroethane.

Hazardous Material - Material that poses a threat to human health or the environment. Hazardous material is typically toxic, corrosive, ignitable, explosive, or chemically reactive.

Integrated Product Team (IPT) - A team established to network functional requirements and deliver integrated program guidance, strategies and solutions.

Life Cycle Costs (of Hazardous Material) - Direct and indirect costs attributable to hazmats during the life of the system, including acquisition, manufacture, supply, use, storage, inventory control, treatment, handling, transportation, recycling, emission control, training, emergency response, work place safety, labeling, hazard assessments, engineering control, personal protective equipment, medical monitoring, regulatory overhead, spill contingency, disposal, remedial action, and liability.

Materials Engineering Section - The organization established in San Antonio Air Logistics Center, Directorate of Technology and Industrial Support, to provide engineering and technical support to the F-5 Pollution Prevention IPT. The office symbol is SA-ALC/TIESM.

Ozone Depleting Chemicals - Chemicals that, when released into the atmosphere, result in the destruction of the earth's stratospheric ozone layer. They include Chlorofluorocarbons (CFCs), halons, and other substances as classified by the Clean Air Act of 1990. The term is synonymous with the legal term ODS (Ozone Depleting Substance) and a previously used term OLDS (Ozone Layer Depleting Substance). There is a good discussion of ODCs and how they destroy the ozone in Chapter 6 of *Acquisition Pollution Prevention: AFMC Implementation Guide* (21:29-33)

Pollution Prevention - Any practice which reduces the amount of any hazardous materials (including radioactive) entering any waste stream or otherwise released into the environment prior to end-of-pipe recycling, treatment, or disposal; and

reduces the hazards to public health and the environment associated with the release of such substances, pollutants or contaminants.

Pollution Prevention Technical Support Division - The organization established in HQ AFMC, Directorate of Engineering and Technical Management, to provide engineering and technical support to the AFMC Pollution Prevention IPT. The office symbol is HQ AFMC/ENX.

Substitute - Any chemical or process used to eliminate the need for an ODC or hazardous material. Also referred to in this document as an alternate.

Toxic Chemical - Any substance listed in Section 313 of the Superfund Amendment and Reauthorization Act of 1986.

Volatile Organic Compounds - Organic substances that react rapidly with nitrous oxides in air and in the presence of sunlight to form oxidants (smog).

Waste Minimization - The reduction of the quantity or toxicity of a residual waste that is generated and subsequently processed, stored, or disposed; its reduction minimizes present and future threats to human health and the environment.

Appendix D: Acronyms

The following acronyms (23:Appendix 2) have been used throughout this document. They are summarized here for the convenience of the reader.

AF - Air Force

AFB - Air Force Base

AFCEE - Air Force Center for Environmental Excellence

AFIT - Air Force Institute of Technology

AFLC - Air Force Logistics Command. The primary supporting command. Consolidated with Air Force Systems Command into Air Force Materiel Command. The headquarters was located at Wright-Patterson AFB, Ohio.

AFMC - Air Force Materiel Command. The command with "cradle-to-grave" responsibility for Air Force weapons systems. The result of the consolidation of Air Force Systems Command and Air Force Logistics Command. The headquarters is located at Wright-Patterson AFB, Ohio.

AFSC - Air Force Systems Command. The command responsible for the initial acquisition of Air Force weapons systems. Consolidated with Air Force Logistics Command into Air Force Materiel Command. The headquarters was located at Andrews AFB, Virginia.

ALC - Air Logistics Center

ASC - Aeronautical Systems Center. Formerly Aeronautical Systems Division. Renamed upon the consolidation of Air Force Systems Command and Air Force Logistics Command into Air Force Materiel Command. Responsible for all weapon system acquisition and development. Primarily located at Wright-Patterson AFB, Ohio, with a geographically separated organization at Eglin AFB, Florida.

ASD - Aeronautical Systems Division. See ASC.

CFC - Chlorofluorocarbon.

DoD - Department of Defense.

EPA - Environmental Protection Agency.

EPC. Environmental Protection Committee.

HAZMAT - A commonly used abbreviation for hazardous material. Material that poses a threat to human health or the environment. Hazardous material is typically toxic, corrosive, ignitable, explosive, or chemically reactive.

HSC - Human Systems Center. Formerly Human Systems Division. Renamed upon the consolidation of Air Force Systems Command and Air Force Logistics Command into Air Force Material Command. Responsible for human systems integration and all human related issues for the Air Force. Primarily located at Brooks AFB, Texas, with geographically separated organizations at Wright-Patterson AFB, Ohio.

HSD - Human Systems Division. See HSC.

HQ - Headquarters.

IPD - Integrated Product Development.

IPT - Integrated Product Team. A team established to network functional requirements and deliver integrated program guidance, strategies and solutions.

OCR - Office of Collateral Responsibility.

ODC - Ozone Depleting Chemical. Chemicals that, when released into the atmosphere, result in the destruction of the earth's stratospheric ozone layer. They include Chlorofluorocarbons (CFCs), halons, and other substances as classified by the Clean Air Act of 1990. The term is synonymous with the legal term ODS (Ozone Depleting Substance) and a previously used term OLDS (Ozone Layer Depleting Substance).

OLDS - Ozone Layer Depleting Substance. See ODCs.

OPR - Office of Primary Responsibility

PPM - Pollution Prevention Management.

PPP - Pollution Prevention Program.

SAB - Scientific Advisory Board

SPO - System Program Office

TO - Technical Order

TORP - Technical Order Review Program

USAF - United States Air Force.

VOC - Volatile Organic Compounds. Organic substances that react rapidly with nitrous oxides in air and in the presence of sunlight to form oxidants (smog).

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Vita

Janice M. Gavern was born on 24 April 1949 in Scranton, Pennsylvania. She graduated from South Scranton Central Catholic High School in 1967, and joined the Air Force in October of the same year. She spent four years as an enlisted personnel clerk, attaining the rank of sergeant. At the end of her enlistment she entered the Air Force Reserve. She worked for four years as a postal employee, began taking college classes at night, and continued working as a Air Force Reserve personnel clerk. In 1975 she cross-trained in the Reserves into the aircraft maintenance career field (C-130s), and in 1976 she became a reciprocating engine mechanic (C-123s). She attained the rank of technical sergeant. She began working for Aeronautical Systems Division in 1978 as a co-operative education student employee. In June, 1981 she graduated from Wright State University with a BS in Psychology, and became a full-time engineering psychologist. She worked for the Life Support System Program Office, and for Crew Station Design Facility, a flight similation applied research facility. She applied and was accepted for direct commissioning as an aircraft maintenance officer in the Reserves. She was commissioned a second lieutenant in July1981. From 1981 until 1989, as the unit Weapons Safety Officer, she set up and managed the weapons safety program for the 906 Tactical Fighter Group (F-4s and F-16s) at Wright Patterson AFB, Ohio. In 1989, she became a category B reservist, assigned as an aircraft maintenance officer to San Antonio Air Logistics Center, Proven Aircraft Division. As a civil service employee, she became a manpower, personnel, and training analyst in the IMPACTS office. She worked for the Development Planning and Program Development Program Offices. In 1992 she was approved for long-term, full-time training at the Air Force Institute of Techonology (AFIT). She graduated from AFIT on 21 September 1993 with a Master of Science degree in Logistics Management, Acquisition Logistics specialty. She is currently a GS-13 in civil service, and a Captain in the Air Force Reserves. She is a member of the national and local

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This study developed a pollution prevention management program for the F-5 aircraft, and described its utility and applicability as a generic framework for similar programs. A representative set of F-5 technical orders was analyzed by hand, and the identified chemicals, materials, and processes were loaded into a spreadsheet data base for additional analysis. The Environmental Protection Agency EPA 17 chemical list, and lists of ozone depleting chemicals (ODCs) were used as criteria to identify, for minimization, reduction, or elimination from use on the F-5, a hazardous material (hazmat) subset of those chemicals and materials which had already been identified. The identified hazmat substances were then "rolled-up" into an F-5 Pollution Prevention Management Plan. Program management use and implementation of the information set out in such a plan were also described. Recommendations for additional research and development, and for required tools were included. Finally, actual examples of all of the material created were attached to the document.

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